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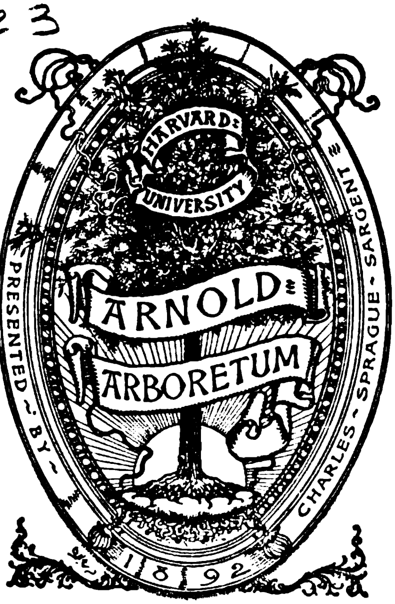

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PRESENTED ~ BY ~ CHARLES ~ SPRAGUE ~ SARGENT
1892

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Vol. 22, part 2, issued December 18, 1905, contains descriptions of the families Saxifragaceae and Hydrangeaceae by Dr. J. K. Small and Dr. P. A. Rydberg; the Cunoniaceae, Iteaceae and Hamamelidaceae by Dr. N. L. Britton; the Pterostemonaceae by Dr. J. K. Small; the Altingiaceae by Percy Wilson and the Phyllonomaceae by Dr. H. H. Rusby.

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CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
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ASTRAGALUS AND ITS SEGREGATES AS REPRESENTED IN COLORADO

By PER AXEL RYDBERG

NEW YORK
1906

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 32: 657-668. 1906]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 32 : 657–668. 1906.]

Astragalus and its segregates as represented in Colorado

PER AXEL RYDBERG

Linnaeus had two genera, *Astragalus* and *Phaca*, the former with a 2-celled, coriaceous or membranous pod and the latter with a 1-celled, papery pod. As more species have become known these characters do not hold, as there are many species which have the pods partly 2-celled, and the texture of both the 1-celled and 2-celled pods varies. The only reasonable ways to treat these two genera, are to merge them into one or to divide them into several. The latter was tried by Torrey and Gray in their flora. When still more species became known, Dr. Gray saw that he had to propose a number of genera in order to be consistent, gave the method up, and merged all the species into *Astragalus.* He was followed by Dr. Watson. In the Old World the segregation was begun by Medicus, and continued by Opiz, Fourreau and Steven. The latter proposed not less than 24 new genera. It seems that these should cover all the forms that have been included in *Astragalus*, but this is not the case. In the Old World, the completely 2-celled series is best represented, but in America the 1-celled or incompletely 2-celled forms are predominant. The segregation into several genera was renewed in Dr. Britton's Manual and carried somewhat further in Dr. Small's. The Colorado genera and species may be disposed as follows :

Key to the genera

- Leaves pinnate or unifoliolate.
  - Pods 2-celled, with a perfect partition.
    - Pods fleshy, indehiscent or very tardily dehiscent. 1. GEOPRUMNON.
    - Pods membranous, leathery or woody, dehiscent.
      - Pods not inflated.
        - Pods ovoid or oblong, rarely almost didymous, terete or flattened vertically, leathery or woody. 2. ASTRAGALUS.
        - Pods linear, more or less flattened laterally, membranous. 3. HAMOSA.
      - Pods strongly inflated, papery. 4. CYSTIUM.
  - Pods 1-celled, the partition, if any, rudimentary.
    - Lower suture strongly intruded, making the pod sagittate or obcordate in cross-section ; pods membranous, rarely leathery. 5. TIUM.

Lower suture not intruded or merely slightly so; pods in the latter case woody.
Pods strongly inflated, papery. 14. PHACA.
Pods not inflated, or slightly so, membranous to woody.
Pods with a partial partition, formed by the inflexion of the lower suture.
Pods membranous. 6. ATELOPHRAGMA.
Pods woody.
Pods stipitate; leaves unifoliolate. 7. JONESIELLA.
Pods sessile; leaves pinnate.
Calyx-tube short, campanulate, equaling or shorter than the lobes; tall glabrous plants. 8. PHACOPSIS.
Calyx-tube cylindrical, longer than the lobes; low, cespitose, cinerous or villous plants. 9. XYLOPHACOS.
Pods without a vestige of a partition.
Pods not with two grooves on the upper side (or, if slightly grooved, sessile).
Pods with a fleshy epicarp, in fruit cross-ribbed; leaflets obscurely articulated to the rachis, fleshy, narrow. 10. CTENOPHYLLUM.
Pods without fleshy epicarp; leaflets distinctly articulated to the rachis.
Pods woody or at least leathery, flattened or slightly intruded on the lower side.
Calyx cylindrical; flowers large; plant mostly low and cespitose. 9. XYLOPHACOS.
Calyx campanulate; flowers small.
Corolla yellow; calyx-lobes linear-lanceolate, equaling the tube; stipules united; stem low. 12. CNEMIDOPHACOS.
Corolla purple; calyx-lobes triangular, much shorter than the tube; stipules free or nearly so; stem tall and slender. 11. MICROPHACOS.
Pods membranous, usually more or less flattened laterally, with both sutures prominent.
Leaves spinulose-tipped; pods 1–2-seeded. 15. KENTROPHYTA.
Leaves not spinulose-tipped; pods several- to many-seeded. 16. HOMALOBUS.
Pods with two grooves on the upper side, stipitate. 13. DIHOLCOS.
Leaves digitately trifoliate. 17. OROPHACA.

1. GEOPRUMNON Rydb.; Small, Fl. SE. U. S. 615. 1903.

Besides by the type, *G. crassicarpum* (Nutt.) Rydb., the genus is represented by:

Geoprumnon succulentum (Richardson) Rydb.
Astragalus succulentus Richardson, Franklin Journey 746. 1823.
Astragalus prunifer Rydb. Mem. N. Y. Bot. Gard. **1**: 239. 1900.

2. ASTRAGALUS L. Sp. Pl. 755. 1753.

As the type, I regard *A. christianus* L., which was an article of food in the desert regions of Syria and the Holy Land. The genus is represented in Colorado by: *A. mollissimus* Torr., *A. Bigelowii* A. Gray, *A. anisus* Jones, *A. canadensis* L., *A. coloradensis* Rydb., *A. nitidus* Dougl. (*A. adsurgens* Hook.; not Pall.), *A. sulphurescens* Rydb., *A. virgultatus* Sheld. and *A. goniatus* Nutt.

3. HAMOSA Medic. Vorles. Churpf. Phys. Ges. 2: 376. 1787.

The type of this genus was *Astragalus hamosus* L. To it belongs, beside *H. Nuttalliana* (DC.) Rydb. and *H. leptocarpa* (T. & G.) Rydb. already named, also the following:

Hamosa scaposa (A. Gray) Rydb.
Astraglus scaposus A. Gray Proc. Am. Acad. **13**: 366. 1878.

4. CYSTIUM Stev. Bull. Soc. Nat. Mosc. 4: 268. 1832.

This genus was based on *Astragalus Cicer* L., *A. Pallasii* Sprengel and *A. physodes* L. Congeneric with these are:

Cystium diphysum (A. Gray) Rydb.
Astragalus diphysus A. Gray, Pl. Fendl. 34. 1849.
Cystium ineptum (A. Gray) Rydb.
Astragalus inceptus A. Gray, Proc. Am. Acad. **6**: 525. 1865.

5. TIUM Medic. Vorles. Churpf. Phys. Ges. 2: 373. 1787.

This was based on *Astragalus sulcatus* L. The typical Colorado species of this genus are:

Tium Drummondii (Dougl.) Rydb.
Astragalus Drummondii Dougl.; Hook. Fl. Bor. Am. **1**: 153. 1831.
Tium racemosum (Pursh) Rydb.
Astragalus racemosus Pursh, Fl. Am. Sept. 740. 1814.
Tium scopulorum (Porter) Rydb.
Astragalus scopulorum Porter, in Porter & Coult. Syn. Fl. Colo. 24. 1874.

I refer to it also the following, which although not closely related to the type fit better in this genus than in any other:

Tium alpinum (L.) Rydb.
Astragalus alpinus L. Sp. Pl. 760. 1753.

Tium sparsiflorum (A. Gray) Rydb.

Astragalus sparsiflorus A. Gray, Proc. Acad. Phila. **1863**: 60, hyponym. 1863. — Proc. Am. Acad. **6**: 205. 1863.

Tium huministratum (A. Gray) Rydb.

Astragalus huministratus A. Gray, Pl. Wright. **2**: 43. 1843.

Tium desperatum (Jones) Rydb.

Astragalus desperatus Jones, Zoe **2**: 243. 1891.

6. **Atelophragma** Rydb. gen. nov.

Caulescent leafy slender herbs with rootstocks. Stipules nearly free both from each other and from the petioles. Leaves pinnate, usually with numerous leaflets. Inflorescence a spike-like raceme. Calyx short, campanulate; lobes slender, subulate. Corolla white or purplish. Pod membranous or papery, more or less compressed laterally, in the typical species decidedly flattened and stipitate; dorsal suture intruding in the pod and forming a partial partition.

The first species below is to be regarded as the type.

Atelophragma aboriginum (Richardson) Rydb.

Astragalus aboriginorum Richardson, Frankl. Journey 746. 1823.

Atelophragma Macounii Rydb.

Astragalus Macounii Rydb. Mem. N. Y. Bot. Gard. **1**: 243. 1900.

Atelophragma glabriuscula (A. Gray) Rydb.

Astragalus glabriusculus A. Gray, Proc. Am. Acad. **6**: 204. 1863.

The following species, although having sessile and more turgid pods, may be included also in the genus:

Atelophragma elegans (Hook.) Rydb.

Phaca elegans Hook. Fl. Bor. Am. **1**: 144. 1831.

Astragalus oroboides americanus A. Gray, Proc. Am. Acad. **6**: 205. 1863.

Atelophragma Brandegei (Porter) Rydb.

Astragalus Brandegei Porter, in Porter & Coult. Syn. Fl. Colo. 24. 1874.

Atelophragma Shearis Rydb.

Astragalus Shearis Rydb. Bull. Torrey Club **31**: 562. 1904.

7. **Jonesiella** Rydb. gen nov.

Stout perennial with a woody root and simple stems. Leaves unifoliolate, thick and veiny; stipules broadly triangular, thin. Racemes 6–8-flowered, axillary. Calyx cylindric, somewhat gibbous, with triangular teeth. Corolla ochroleucous with a purple spot on the keel. Pod stipitate, coriaceous, elliptic, turgid, partially 2-celled by the inflexion of the upper suture.

Jonesiella asclepiadoides (Jones) Rydb.

Astragalus asclepiadoides Jones, Zoe **2**: 238. 1891.

8. **Phacopsis** Rydb. gen. nov.

Stout erect glabrous perennials, more or less branched at the woody base. Leaves pinnate with numerous leaflets; stipules ovate, almost free. Racemes rather many-flowered; flowers nearly sessile; bracts lanceolate. Calyx campanulate; lobes lanceolate-subulate, nearly equaling the tube, at last with spreading tips. Corolla ochroleucous with purple-tipped keel; banner and wings narrow. Pod oblong-ovate, coriaceous, somewhat inflated, with a more or less distinct partial partition formed by the inflexion of the suture.

The first species is to be regarded as the type.

Phacopsis praelongus (Sheld.) Rydb.

Astragalus procerus A. Gray, Proc. Am. Acad. **13**: 369. 1878. Not *A. procerus* Boiss. & Haussk. 1872.

Astragalus praelongus Sheld. Bull. Geol. & Nat. Hist. Surv. Minn. **9**: 23. 1894.

Phacopsis Pattersoni (A. Gray) Rydb.

Astragalus Pattersoni A. Gray in Brandegee, Bull. U. S. Geol. Surv. Terr. **2**: 235. 1876.

Gray, Watson and Sheldon associated *A. Pattersonii* with *A. Fendleri* and *A. Hallii*, but the pod is practically that of *Xylophacos*, *i. e.*, *A. Shortianus* and its allies, but shorter and more inflated. It has a partial partition, although not so prominent as in the preceding. These two species might have been included in *Xylophacos*, but they have a different habit and different calyx.

9. XYLOPHACOS Rydb.; Small, Fl. SE. U. S. 619. 1903.

Besides the type, *X. Shortianus* (Nutt.) Rydb., and *X. missouriensis* (Nutt.) Rydb., the following are found in Colorado:

Xylophacos vespertinus (Sheld.) Rydb.
Astragalus vespertinus Sheld. Bull. Geol. & Nat. Hist. Surv. Minn. **9**: 150. 1894.

Xylophacos amphioxus (A. Gray) Rydb.
Astragalus amphioxus A. Gray, Proc. Am. Acad. **13**: 366. 1878.

Xylophacos uintensis (Jones) Rydb.
Astragalus uintensis Jones, Proc. Calif. Acad. II. **5**: 670. 1895.

Xylophacos pygmaeus (Nutt.) Rydb.
Phaca pygmaea Nutt.; T. & G. Fl. N. Am. **1**: 349. 1838.
Astragalus chamaeluce A. Gray, Bot. Ives' Rep. 10. 1861.
Astragalus Cicadae Jones, Zoe **4**: 35. 1893.

This is somewhat aberrent from the typical species of *Xylophacos*, as its pod is spongy at maturity.

Xylophacos Parryi (A. Gray) Rydb.
Astragalus Parryi A. Gray, Am. Jour. Sci. II. **33**: 409. 1862.

Also somewhat aberrent on account of its long pod inflexed on both sutures, and in this respect approaching the genus *Holcophacos*.

Xylophacos Purshii (Dougl.) Rydb.
Astragalus Purshii Dougl.; Hook. Fl. Bor. Am. **1**: 152. 1831.

Torrey, Gray, Watson and Sheldon placed this species and its allies in the subgenus *Phaca*, while *Astragalus Shortianus* and its closer relatives were placed in *Astragalus* proper. There is only one character to separate the two groups, viz., the long woolly pubescence on the pods in one and the sparse and usually appressed pubescence in the other. Some of the *A. Purshii* relatives have the sutures just as much inflexed as any of the other group. The habit, calyx, etc., are practically the same in both.

Xylophacos Newberryi (A. Gray) Rydb.
Astragalus Newberryi A. Gray, Proc. Am. Acad. **12**: 55. 1876.

Watson placed this in the subgenus *Phaca*, in the same section as *A. Fendleri*, *A. Hallii* and *A. flexuosus*. Scarcely a worse place could have been chosen. The structure of the pod and its pubescence associate it with the preceding and its allies, while the habit is more like a dwarf form of the *A. Shortianus* group.

10. **Ctenophyllum** Rydb. gen. nov.

Stout perennials with often several stems rising from the same root and more or less stoloniferous. Leaves pinnate, with 11–19 linear to filiform leaflets, which are very indistinctly jointed to the rachis; stipules ovate, free from the petioles, but (especially the lower) united back of the stem. Peduncles usually equaling the leaves; raceme short. Calyx cylindro-campanulate, very gibbous at the base on the upper side. Corolla ochroleucous, with narrow petals; keel almost straight. Pod oblong, terete, coriaceous with a subfleshy epicarp, in age cross-wrinkled, with thick and prominent sutures, neither of which is inflexed.

Ctenophyllum pectinatum (Hook.) Rydb.

Phaca pectinata Hook. Fl. Bor. Am. **1**: 141. 1831.

Astragalus pectinatus Dougl.; Hook. *loc. cit.* 142, as a synonym.

11. **Microphacos** Rydb. gen. nov.

Subcinereous perennials with very slender stems. Leaves pinnate with 11–17 linear to oblong leaflets; stipules very broad, triangular, free from the petioles and only the lower more or less united with each other. Racemes many-flowered. Calyx short-campanulate, about 2 mm. long, with very short and broad teeth. Corolla purple, 5–6 mm. long, all petals strongly curved. Pod 6–8 mm. long, coriaceous, cross-wrinkled, wholly 1-celled, 6–7-ovuled, boat-shaped, *i. e.*, lower suture prominent, strongly curved, upper suture nearly straight or curved upwards, flat or slightly sulcate.

The first species is to be regarded as the type.

Microphacos gracilis (Nutt.) Rydb.

Astragalus gracilis Nutt. Gen. **2**: 100. 1818.

Microphacos microlobus (A. Gray) Rydb.

Astragalus microlobus A. Gray, Proc. Am. Acad. **6**: 203. 1863.

12. **Cnemidophacos** Rydb. gen. nov.

Cespitose perennials with a woody caudex; stems short, 1 2 dm. high. Leaves pinnate with many narrow leaflets, cinereous; stipules slightly united with the petioles, but almost wholly united behind the stem forming a sheath. Racemes strict and many-flowered. Calyx deeply campanulate; lobes linear-lanceolate, equaling the tube. Corolla yellow, with narrow petals. Pod coriaceous, oblong-ovoid, rounded below, somewhat depressed above, but with a very sharp suture and hence somewhat 2-grooved.

Cnemidophacos flavus (Nutt.) Rydb.

Astragalus flavus Nutt. in T. & G. Fl. N. Am. **1**: 335. 1838.

Tragacantha flaviflora Kuntze, Rev. Gen. Pl. **2**: 941. 1891.

Astragalus flaviflorus Sheld. Bull. Geol. & Nat. Hist. Surv. Minn. 9: 158. 1894.

This has been placed in the *Eu-Astragalus* division, next after *A. racemosus*, and in a section together with *A. huministratus* and *A. oreganus*, to which it has no relationship. The only similarity is the conspicuousness of the stipules.

13. **Diholcos** Rydb. gen. nov.

Stout erect perennials often forming clumps. Leaves pinnate with many thick leaflets; stipules lanceolate, free. Raceme many-flowered, dense, spike-like; bracts lance-subulate. Calyx campanulate, gibbous at the base on the upper side; teeth subulate-setaceous. Corolla purple, white or ochroleucous; petals only moderately curved and blunt. Pod coriaceous, stipitate, oblong, straight, rounded on the lower suture, deeply 2-grooved above and with a prominent upper suture, 1-celled.

The first species is to be regarded as the type.

Diholcos bisulcatus (Hook.) Rydb.

Phaca bisulcata Hook. Fl. Bor. Am. **1**: 145. 1831.

Astragalus bisulcatus A. Gray, Pac. R. R. Rep. **12**: 42. 1860.

Diholcos decalvans (Gandoger) Rydb.

Astragalus bisulcatus decalvans Gandoger, Bull. Soc. Bot. France 48: xv. 1902.

Diholcos Haydenianus (A. Gray) Rydb.

Astragalus Haydenianus A. Gray in Brandegee, Bull. U. S. Geol. Surv. Terr. **2**: 235. 1876.

14. PHACA L. Sp. Pl. 755. 1753.

The Colorado species are as follows: *Phaca longifolia* (Pursh) Nutt., *P. picta* A. Gray, *P. Candolleana* H. B. K., *P. pauciflora* Nutt., and:

Phaca Eastwoodiae (Jones) Rydb.

Astragalus Preussii sulcatus Jones, Zoe 4: 37. 1893.

Astragalus Eastwoodiae Jones, Zoe 4: 368. 1894.

Phaca artipes (A. Gray) Rydb.

Astragalus artipes A. Gray, Proc. Am. Acad. **13**: 370. 1878.

Phaca cerussata (Sheld.) Rydb.
Astragalus cerussatus Sheld. Bull. Geol. & Nat. Hist. Surv. Minn. **9**: 139. 1894.
Phaca Bodinii (Sheld.) Rydb.
Astragalus Bodinii Sheld. Bull. Geol. & Nat. Hist. Surv. Minn. **9**: 122. 1894.

Sheldon placed this among the *Homalobi* and described the pod as being flat, but all specimens with well-developed fruit show that the species is a typical *Phaca.*

Phaca humillima (A. Gray) Rydb.
Astragalus humillimus A. Gray, in Brandegee, Bull. U. S. Geol. Surv. Terr. **2**: 235. 1876.
Phaca elatiocarpa (Sheld.) Rydb.
Astragalus lotiflorus brachypus A. Gray, Proc. Am. Acad. **6**: 209. 1863.
Astragalus elatiocarpus Sheld. Bull. Geol. & Nat. Hist. Surv. Minn. **9**: 20. 1894.
Phaca Wetherillii (Jones) Rydb.
Astragalus Wetherillii Jones, Zoe **4**: 34. 1893.

15. KENTROPHYTA Nutt. in T. & G. Fl. N. Am. **1**: 353. 1838.

Besides the *K. viridis* Nutt., the following are found in Colorado:

Kentrophyta impensa (Sheld.) Rydb.
Astragalus Kentrophyta elatus S. Wats. Bot. King's Expl. 77. 1871. Not *A. elatus* Boiss. & Bal. 1849.
Astragalus viridis impensus Sheld. Bull. Geol. & Nat. Hist. Surv. Minn. **9**: 118. 1894.
Kentrophyta Wolfii Rydb.
Homalobus Wolfii Rydb. Bull. Torrey Club **31**: 562. 1904.
Kentrophyta aculeata (A. Nelson) Rydb.
Astragalus tegetarius implexus Canby, in Porter & Coult Colo. Add. (no page-number) 1874.
Astragalus aculeatus A. Nelson, Bull. Torrey Club **26**: 10. 1899.

16. HOMALOBUS Nutt. in T. & G. Fl. N. Am. 1: 350. 1838.

The following are the Colorado species: *H. caespitosus* Nutt., *H. wingatanus* (S. Wats.) Rydb.; *H. Clementis* Rydb., *H. tenellus* (Pursh) Britton, *H. campestris* Nutt., *H. decurrens* Rydb., *H. hylophilus* Rydb., *H. tenuifolius* Nutt. and *H. decumbens* Nutt. Also:

Homalobus grallator (S. Wats.) Rydb.

Astragalus grallator S. Wats. Zoe 3: 52. 1892.

Homalobus acerbus (Sheld.) Rydb.

Astragalus acerbus Sheld. Bull. Geol. & Nat. Hist. Surv. Minn. 9: 123. 1894.

Homalobus junciformis (A. Nelson) Rydb.

Astragalus junciformis A. Nelson, Bull. Torrey Club 26: 9. 1899.

Homalobus camporum Rydb. sp. nov.

A cespitose perennial; stems erect, 1–2 dm. high, grayish-strigose; leaves 3–5 cm. long; leaflets 9–15, linear to nearly filiform, rarely oblong, 4–10 mm. long, 0.5–2 mm. wide, silvery-canescent; stipules ovate, somewhat scarious, strigose; raceme 5–10 cm. long; flowers 7–15; bracts subulate; calyx campanulate, white-silky, about 3 mm. long; lobes lance-subulate, about ⅔ as long as the tube; banner about 6 mm. long, white or ochroleucous with purple veins; keel with a narrow purple tip; pod linear, 12–18 mm. long, 2–3 mm. wide, compressed, straight, strigose.

This is rather common on the plains and hills from Alberta to Colorado and Utah and has been known as *Astragalus campestris*, *A. decumbens* and *A. tenuifolius* Nutt. The first of these is a taller plant 3–4 dm. high, more simple; its pod is 2–2.5 cm. long and its keel is broad and blunt. *H. decumbens* has an arcuate pod and in *H. tenuifolius* the calyx-teeth are triangular and only ¼–⅓ as long as the tube. As the type may be assigned:

WYOMING: Bush Ranch, Sweetwater Co., June 10, 1900, *Aven Nelson 7085*.

Homalobus flexuosus (Hook.) Rydb.

Phaca flexuosa Hook. Fl. Bor. Am. 1: 141. 1831.

Astragalus flexuosus Dougl.; Hook. *loc. cit.*, as a synonym.

This and the following differ from the typical species of *Homalobus* in having almost terete instead of flattened pods. The pods are, however, of the same texture, wholly one-celled and with prominent sutures, and the plants are of the same general habit.

Homalobus Hallii (A. Gray) Rydb.

Astragalus Hallii A. Gray, Proc. Am. Acad. **6**: 224. 1863.

Homalobus Fendleri (A. Gray) Rydb.

Astragalus Fendleri A. Gray, Pl. Wright. **2**: 44. 1853.

Homalobus proximus Rydb. sp. nov.

Cespitose perennial, related to *H. flexuosus*; stems erect, 2–3 dm. high, grayish-strigose; leaves 4–6 cm. long; stipules triangular-ovate, glabrous; leaflets 5–11, linear or linear-oblong, obtuse, 5–11 mm. long, 1–2 mm. wide, grayish-strigose; racemes erect, 5–10 cm. long; calyx about 2.5 mm. long, strigose; corolla 4–5 mm. long, white or ochroleucous; pod oblong-linear, terete, glabrous, about 12 mm. long and 3 mm. in diameter, glabrous, acute at the apex, abruptly contracted into a short stipe about equaling the calyx.

COLORADO: Arboles, June, 1899, *C. F. Baker 421*.

Homalobus Salidae Rydb. sp. nov.

Decumbent or ascending perennial; stem 3 dm. or more long; leaves 5–7 cm. long; stipules triangular-ovate, strigose; leaflets 15–21, oblong-oblanceolate to narrowly linear, 8–15 mm. long, 0.5–3 mm. wide, strigose; racemes 10–15 cm. long, lax; pedicels 5 mm. long; bracts minute; calyx campanulate, strigose and slightly black-hairy, about 3 mm. long; teeth short, triangular; corolla about 8 mm. long, purple-veined; pod narrowly linear-oblanceolate, terete or nearly so, 2–2.5 cm. long, 2 mm. in diameter, finely strigose, very acute at the apex and gradually tapering into a short stipe below.

COLORADO: Salida, August 3, 1896, *C. L. Shear 3468*.

Homalobus macrocarpus (A. Gray) Rydb.

Phaca macrocarpa A. Gray, Pl. Fendl. 36. 1849.

Astragalus lonchocarpus Torr. Pac. R. R. Rep. **4**: 80. 1856.

This species is doubtfully referred to *Homalobus*. It may represent a monotypic genus of its own. The relationship is however much closer to *Homalobus* than to *Phaca*, with which it has been associated.

17. OROPHACA (T. & G.) Britton, Man. 555. 1901.

Besides *O. sericea* (Nutt.) Britton, the following are found in Colorádo:

Orophaca tridactylica (A. Gray) Rydb.
Astragalus tridactylicus A. Gray, Proc. Am. Acad. **6**: 527. 1866.
Orophaca aretioides (Jones) Rydb.
Astragalus sericoleucus aretioides Jones, Cont. West. Bot. **8**: 13. 1898.

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THE DELTA OF THE RIO COLORADO

BY

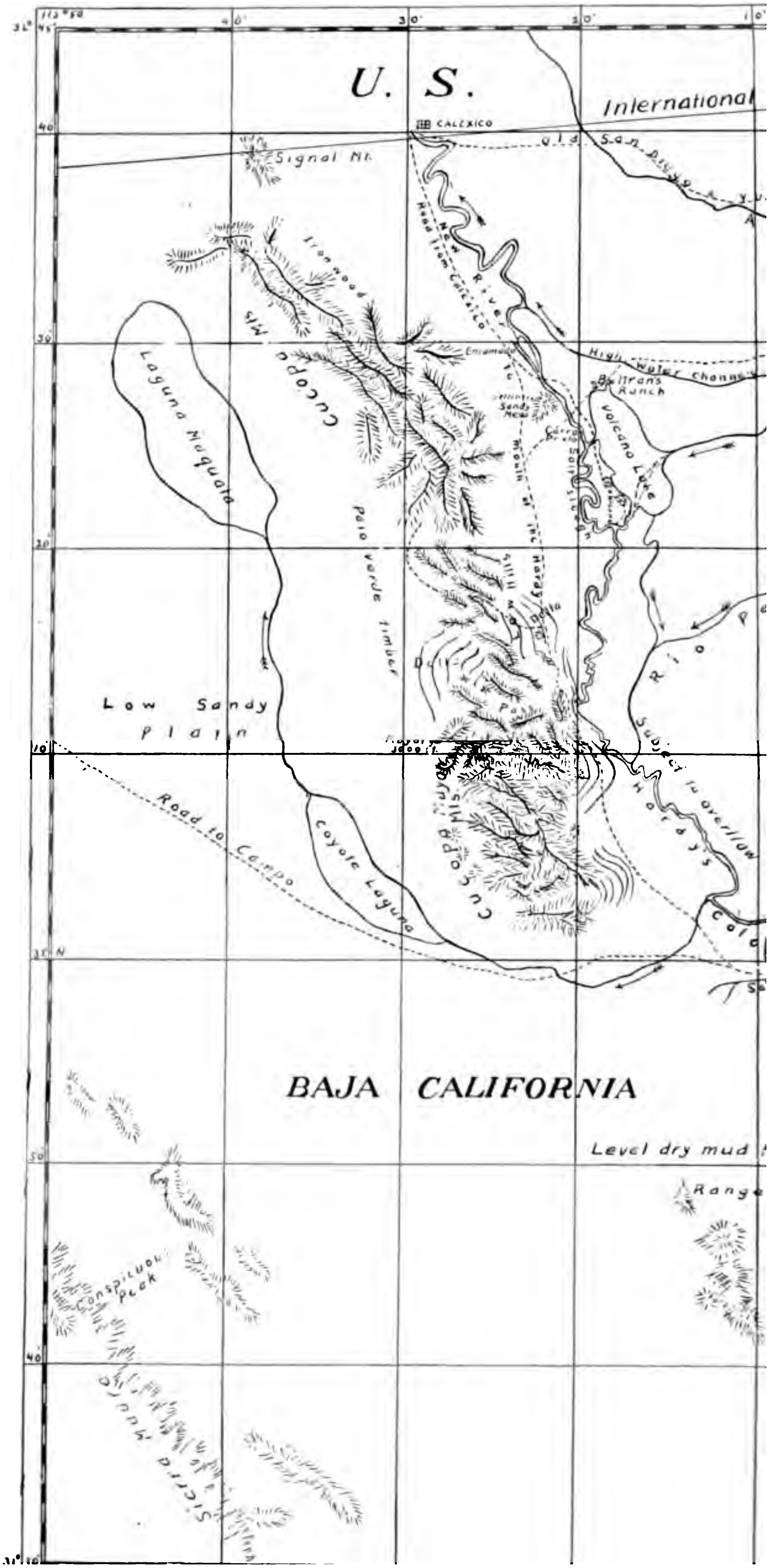
DANIEL TREMBLY MACDOUGAL

WITH MAP BY

GODFREY SYKES

NEW YORK
1906

[Reprinted from the Bulletin of the American Geographical Society, January, 1906]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Signal Mt.
Old San Diego
Ironwood
Cucopa Mts
New River
Road from Calexico
Laguna Maquata
Encamada
High water channel
Beltran's Ranch
Sandy Mesa
Cerro Prieto
Volcano Lake
Salt Slough
Mouth of the Hardy
Palo Verde timber
Hills
Hardy
Delta
Rio P
Low Sandy Plain
Road to Campo
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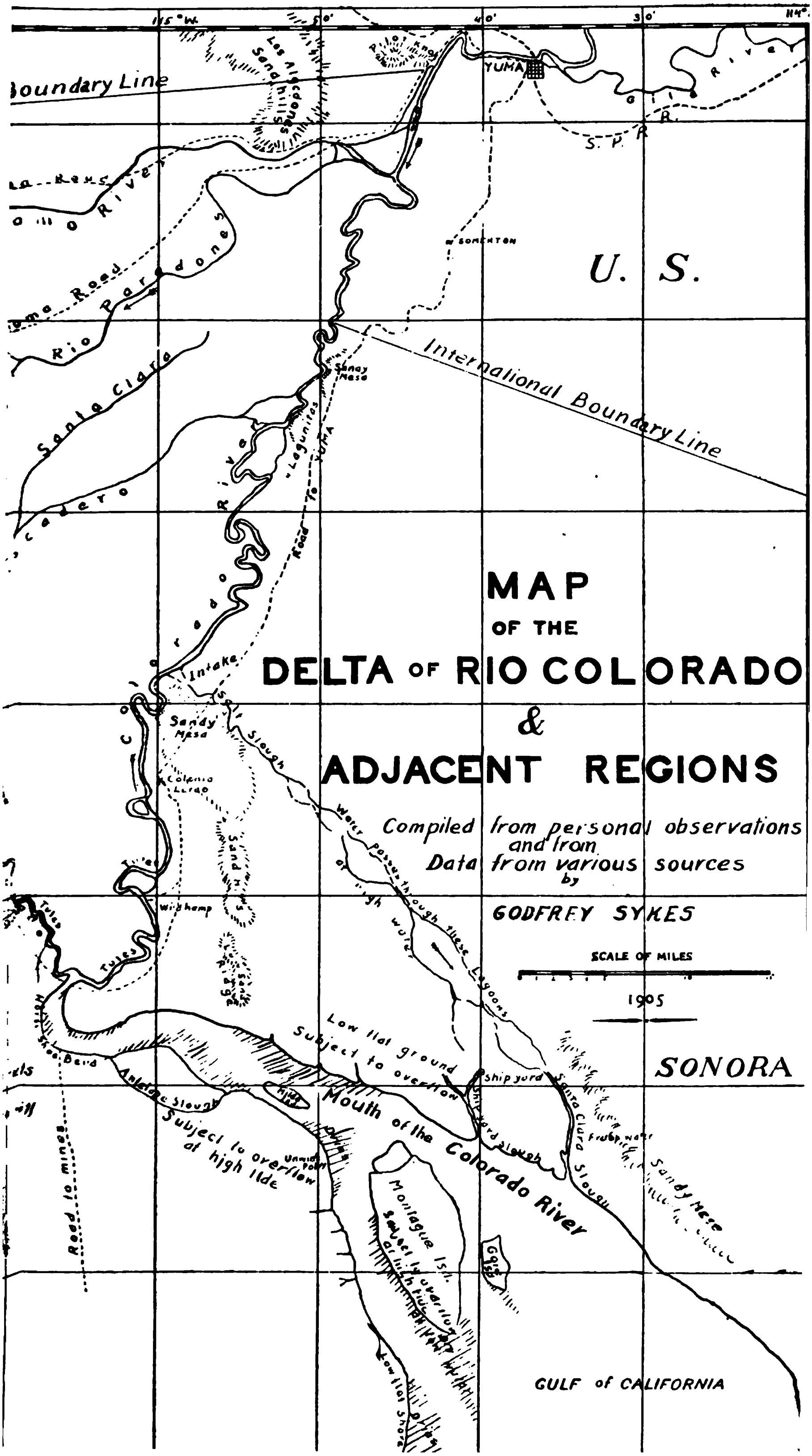


MAP
OF THE
DELTA OF RIO COLORADO
&
ADJACENT REGIONS

Compiled from personal observations
and from
Data from various sources
by
GODFREY SYKES

SCALE OF MILES

1905

THE DELTA OF THE RIO COLORÁDO.

BY

DANIEL TREMBLY MACDOUGAL.

WITH MAP BY GODFREY SYKES.

The Rio Colorado, the Nile of America, rises in the higher mountains of Wyoming and Colorado, cuts its way through cañons, mile deep for hundreds of miles, to the western edge of the great plateau, where it emerges to flow through the most arid desert in North America, finding its way into the head of the Gulf of California in a sub-tropical climate two thousand miles from its source. Here it spreads its delta with one edge to the westward against the huge sand-dunes or " algodones " of southern California, while the other stick of the fan lies far to the eastward along the margin of the Sonora mesa, where the jungle of the swamp meets the sparse vegetation of the arid gravel slopes and bluffs in striking contrast. Between the deserts to the west and to the east the radiating ribs of the delta fan, variously intertwined with subdivisions of the river, project against the Cucopa Mountains, which now rise clear-cut and cameo-like and now loom hazily against the southern horizon. The delta and the range beyond it, like many such "unknown" regions, have been visited in desultory fashion by the prospector, the hunter and trapper, and the nearest camps teem with stories of adventures, hazards, and disasters among its sloughs, tidal bores, volcanoes, sunken saline plains, and arid mountains.

The river runs at a low stage during three-fourths of the year, but in May the melting snows of the highlands swell the stream in an increasing volume until a height of a hundred feet above low-water mark is attained in the cañons during June and July, and the entire delta is practically submerged, or awash. This is the ordinary behaviour of the "great river," the only name by which it is known at present to the near-by Indian, and in accordance with immemorial custom he sows his crops in the mud of the receding waters in August and September. Once or twice in the lifetime of a man, or at intervals of fifteen to twenty years, a similar rise is caused by rains on the lower slopes in February and March resulting in serious disturbances to all life in the delta. The expedition of which the author was a member made its way through the delta on the crest of such a flood during the present year (1905). Previous visits to various portions of this interesting region had been made in company with Mr. Godfrey Sykes, who has also made several independent voyages through the estuary to the gulf. For two centuries occasional parties, attracted by the call of the " red gods " or by the lure of profit, have gone down the river to the sea, and perhaps not more than one in three of such adventurers have escaped hardship or disaster in some form.

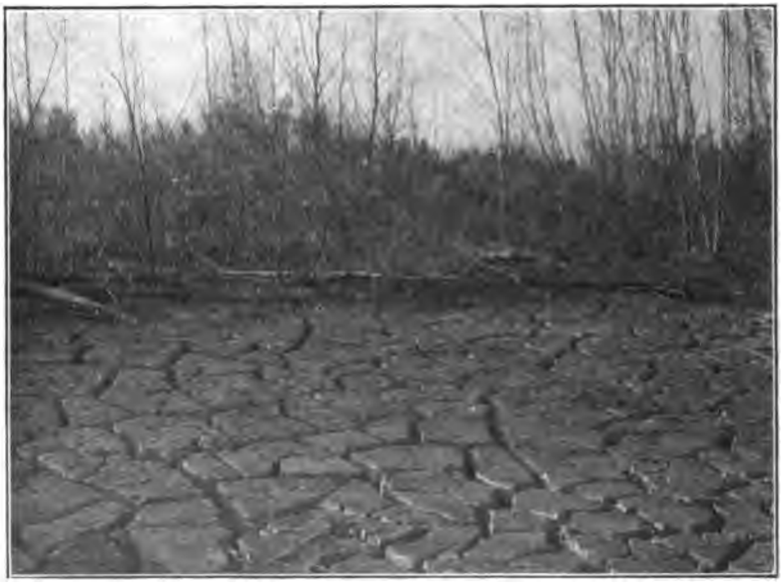


FIG. 1.—MUD FLATS SHOWING CONCHOIDAL FRACTURE WHEN DRY. MELONS AND CORN ARE PLANTED IN LARGE BOWL-SHAPED DEPRESSIONS DUG DOWN BELOW THE FRACTURES.

One of the most notable experiences of this character was that of Messrs. Skyes and MacLean in 1890, who, having started around the world in a small sloop from the head of the delta, had their boat and supplies burned on the eastern shore of Baja California, three hundred miles from civilization and a hundred miles from the nearest fresh water. Then followed a march across a veritable "Jornada del Muerto" not attempted successfully before or since by white or Indian, which was won out by an intimate knowledge of the ways of the desert and by sheer capacity for endurance. Half of the distance was made by reliance upon oysters gathered from the desolate shore, and the water from hot salty springs searched out by following the converging trails of coyotes, the same animal figuring on a bill of fare not too ornate; days of cruel plodding in the fierce heat of a tropical sun across a plain of yielding flaky saline deposit, then through all but impassable mud flats, and tule swamps of the delta to a hunter's camp found with a nicety that showed a marvellous blend of instinct with cool calculation.

The only parallel to this desert journey is to be found in the record of the Pattie party in 1828. Having been despoiled at the mouth of the Gila River by the Yuma Indians, they descended the river in dugout canoes rigged in pairs as catamarans, in search of settlements of whites. Encountering the tides and bores in the estuary, the return upstream was attempted only to be checked by a February flood, and the boats were abandoned. Under guidance of the Indians, a march was made across the desert to the snow-covered mountains to the southwestward, during two days of which the party was entirely without water. Crossing a plain ankle deep in sand, the exhausted travellers with difficulty threaded their way through the thickets of cacti to a small stream issuing from a cañon at the base of the mountains, and from here made their way to the now extinct mission of Santa Catalina and to other adventures. Neither has this journey yet been duplicated by white men.

The main channel of the river was mapped by Derby and Heintzelman in 1852, and by Ives in 1857, but its course as traced by these earlier voyagers coincides as little with the stream of the present day as with the tracings made three centuries ago by Spanish priests and soldiers. During all this period, however, the river has been cutting away at the edge of the Sonora desert at two or three points. It makes a long reach to the westward directly away from the mesa at Yuma, then a slight curve to the northward, after which it leads away to the south, passing into many involved convolutions, one of which strikes the mesa at a point marked " Sandy Bluff " but a few miles below the international boundary. A short distance down stream (eight or ten miles) the current swings back against the gravel bluffs, and then leaves the mesa to touch it again only at the gravel or sand bluffs near the head of tidal action usually known as the "Colony Mesa." The cutting action of the current is rapid and continuous at these exposures. Small rivulets of sand and gravel trickle continuously down the steep slopes of the cliffs, and occasionally large masses are detached and fall into the water with no little commotion.

At these places may be found within a compass of a hundred feet the most vivid contrasts of rank swamp vegetation and water-loving plants having broad leaves and delicate tissues with the toughened, spinose, and hairy, xerophytic forms of the desert. The presence of the moist area of the delta has but little effect upon the climate of contiguous arid regions, although a popular supposition to the contrary promises fairly to be immortal. The relative humidity here is often as low as seventeen per cent. within fifty feet of the margin of the water. During the recent visit to this region however, clouds of mosquitoes from the delta had been blown for many miles across the sandy plains, and these pestiferous swarms among the creosote and sage bushes gave a deceptive but unalluring appearance of alteration of climatic factors.

The above conditions are well illustrated by the following data, obtained in 1904. For purposes of comparison, observations were made on the alluvial plain among the leafless willows and poplars during the dry season, and the results were:—

January 28.	4:30 P.M.	60° F.	17% rel. hum.
January 28.	6:30 P.M.	55° F.	15% rel. hum.
January 28.	8:00 P.M.	51° F.	18% rel. hum.
January 29.	12:45 A.M.	32° F.	41% rel. hum.
January 29.	1:20 A.M.	30° F.	50% rel. hum.
January 29.	6:00 A.M.	29° F.	66% rel. hum.
January 29.	6:25 A.M.	27° F.	70% rel. hum.
January 29.	7:00 A.M.	38° F.	60% rel. hum.
January 29.	7:40 (Sun on instrument)		36% rel. hum.

Observations were also made on the "Upper Mesa" or "Line Mesa" at a distance of less than a hundred and fifty feet from the margin of the bank, among typical desert shrubs which were scattered over the gravel plain in characteristic fashion. The following data were obtained:—

January 30.	4:40 P.M.	70° F.	19% rel. hum.
January 30.	4:50 P.M.	68° F.	16% rel. hum.
January 30.	7:00 P.M.	54° F.	15% rel. hum.
January 30.	8:30 P.M.	48° F.	27% rel. hum.
January 31.	7:30 A.M.	45° F.	29% rel. hum.
January 31.	6:30 A.M.	44° F.	30% rel. hum.

The high level of the March flood, being fairly uniform, is very useful in determining certain topographical features of the delta and its relation to the adjacent territory. Thus an old trapper who had frequented the river twenty-five years ago had left behind him the tradition that a channel left the main river above tidewater, and seventy-five miles from the mouth, and flowed southeasterly into the head of the Gulf of California—an assertion which had never been confirmed. The only known depression suitable for such a flood-waterway would be offered by the Santa Clara River,a shallow stream which heads back from the Gulf into the Sonora desert some distance from the river and sends a feeble current of salty water through its shallow reaches to the sea. An investigation of this feature from a camp near the head of the Santa Clara showed that the reddish waters of the Colorado left the main channel just above the "Colony Mesa" and flowed in great volume through a depression into the Santa Clara, forming a navigable stream which might easily, with a shift of the cutting action of the current, become the main way of the Colorado.

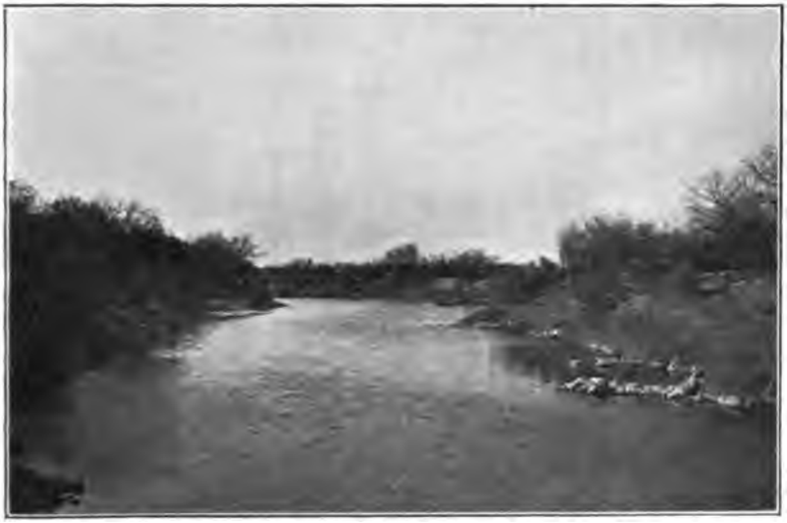


FIG. 2.—THE SANTA CLARA RIVER, ONE OF THE HIGH-WATER OUTLETS OF THE COLORADO RIVER, NEAR COLONIA LERDO.

An immense amount of sediment, which has been estimated at sixty million tons yearly, is carried down into the delta and deposited on the bars and banks of the various channels, giving rise to the assertion that appreciable construction of solid land has occurred within the observation of persons now living. This view is supported by the fact that the willows and poplars, which do not inhabit the lowest land moistened with brackish water, have advanced about ten miles farther south within the memory of certain Indians, and also by the formation of Hilda Island in the lower reach of the river, which is recorded on the accompanying map for the first time, and which was first noted by Mr. Godfrey Sykes while descending the river in the sloop Hilda in 1890.

The sparse records of the last century show that islands have appeared and disappeared in the lower reaches of the river in a very capricious fashion. The funnel-shaped head of the Gulf of California shoals abruptly in the mouth of the river, and flood-tides reach a height of forty-one feet above low water. These conditions lead to the formation of a bore which sweeps upstream at the close of the ebb in a comber four to six feet in height, striking the exposed shores with great violence and starting new points of erosion and shoal deposit. Within the region affected by the tides, the tules and tall

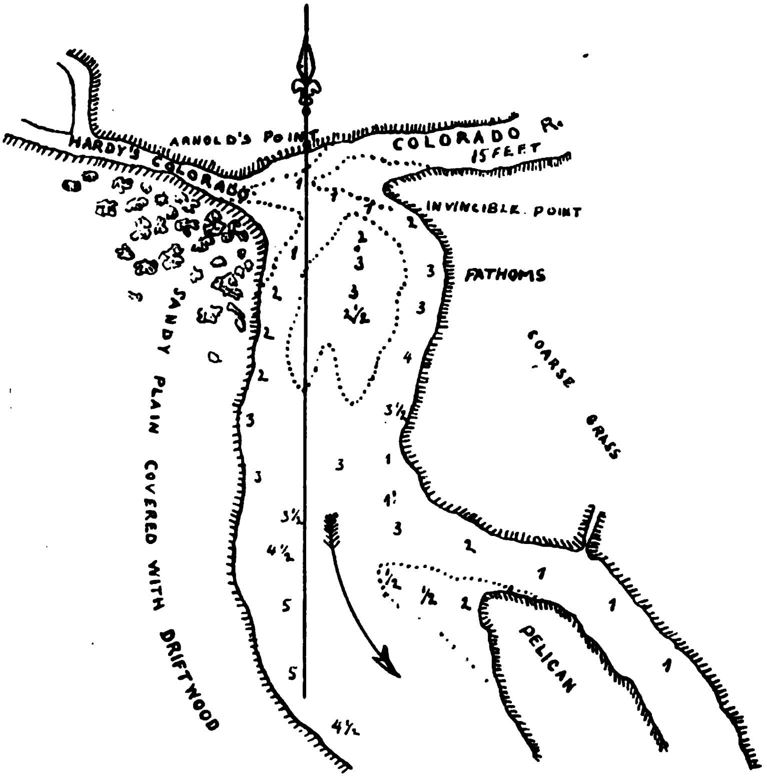
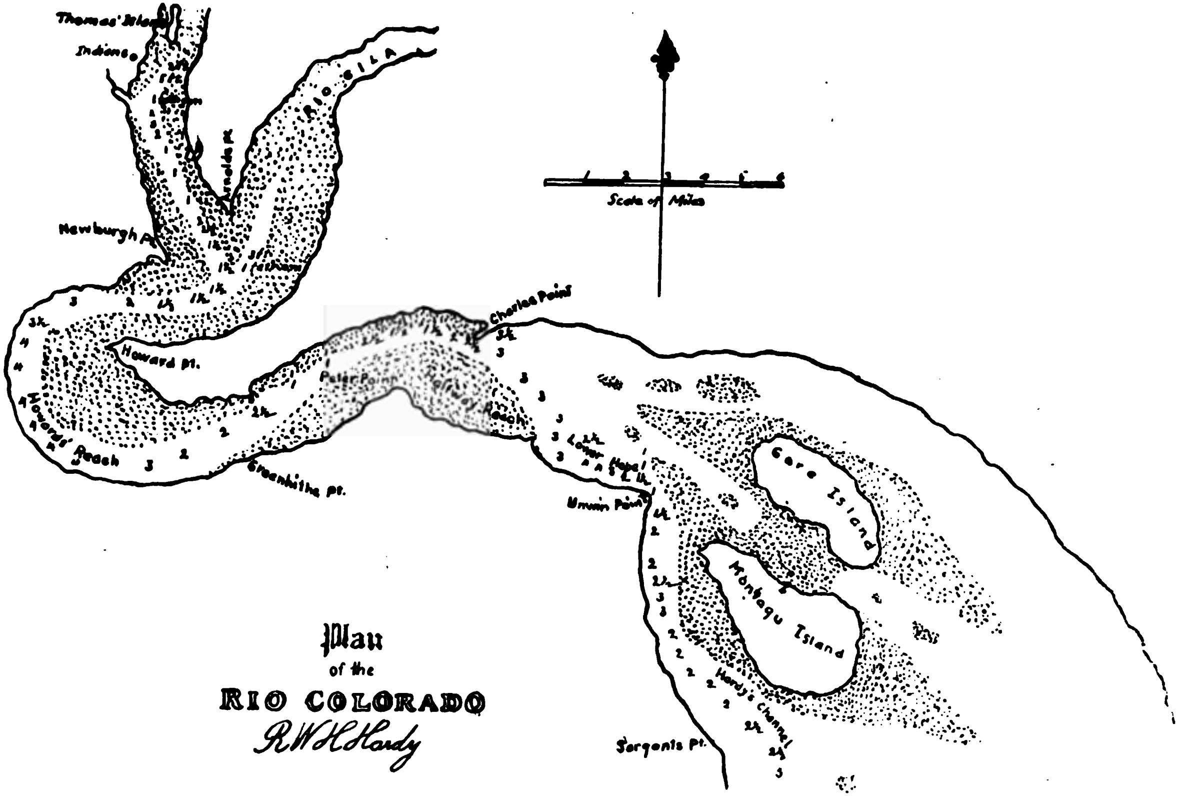


FIG. 3.—SKETCH OF THE MOUTH OF THE COLORADO RIVER MADE BY LIEUTENANT DERBY IN 1850, DIFFERING SLIGHTLY FROM THE GENERAL MAP OF THE WHOLE RIVER MADE BY HIM AND MAJOR HEINTZELMAN.



Plan
of the
RIO COLORADO
R W H Hardy

vegetation along the shores may be seen to be leaning upstream as a result of the smashing effect of the uprushing bore, which is a serious menace to all but the largest craft which seek to navigate the river.

In 1826 Lieut. R. W. H. Hardy, "Commissioner of the General Pearl and Coral Fisheries of London," made up the lower reaches of the river in a small vessel to a point where a wide stream was seen coming in from the northwestward, which he mistook for the Colorado. This stream is now known as Hardy's Colorado, and is the channel which binds together the ribs of the delta fan, gathering the water which leaves the Colorado in the Pescadero, Paredones, and other unnamed channels, and emptying it back into the main river before it reaches the Gulf. Not all of the water, however, which leaves the main river returns to it, or finds a way to the sea.

The Hardy has its origin in a shallow body of water known as Volcano Lake, which lies in the western part of the delta on the crest of a gentle swell, and which receives the water of the Paredones running out of the Colorado. To the northwestward the drainage from this lake is toward the Salton basin, which is from fifty to a hundred and twenty-five miles in diameter, and which has its salt-covered floor more than three hundred feet below sea-level. Water which flows out of Volcano Lake through New River to the westward, as well as other channels coming directly or indirectly from the Colorado, trickles over the edge of the giant bowl and rushes down its steep slopes, forming a lake in the bottom of the basin. Such floods, re-forming Salton Lake, occurred in 1828, 1849, 1861-2, 1891, 1905, and perhaps in other years in which records are not available. This last flood poured enough water into the basin to form a lake with an area of about six hundred square miles, which in November, 1905, was reported to be increasing in depth and extent.

According to Indian traditions, this great basin has been filled to the brim in times past, abounded in fish, and people lived along its margin in many villages. "Poco a Poco" the floods receded, however, until a desert remained. The floods within historic times have in some instances poured vast quantities of water into the basin; but this generally evaporates in a few months in the blazing heat of the sun, which gives temperatures of about one hundred and twenty degrees Fahrenheit in the shade, and which has an evaporating capacity of twelve to twenty feet of water yearly.

The intake of additional quantities of water into the sunken basin is now facilitated by a huge canal led off from the Alamo Slough and the Colorado River for the purpose of irrigating lands lying around the upper rim of the bowl, and the reappearance of the ancient sea as a permanent feature is by no means among the impossibilities.

Another basin below the sea-level connected with the delta is to be found on the farther side of the Cucopa Mountains, which bound the delta on the southwest. During floods the waters bathe the entire eastern foot of the mountains, and great volumes find a way around the southern end of the range to this basin, filling the depression in two places known as the Laguna Maquata and Coyote Laguna. These are also soon dried up after the supply of water ceases.

The topographical features described above combine to make the Cucopa Mountains, which are to be reckoned as among the most arid on the continent, a peninsular ridge at high water connected with dry land by a narrow strip a few feet only above sea-level, and extending northwestward across the international boundary.

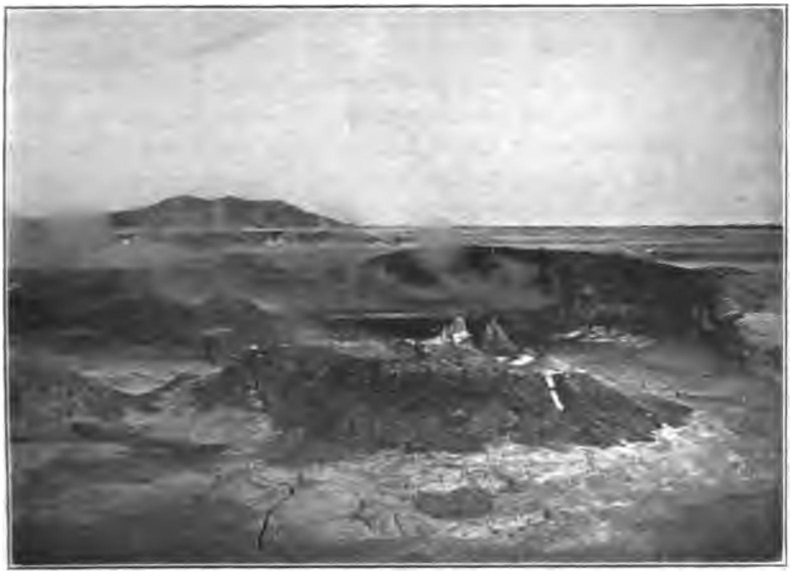


FIG. 5.—ACTIVE MUD-VOLCANOES NEAR VOLCANO LAKE. CERRO PRIETO, THE LARGEST OF THE GROUP SEEN IN THE DISTANCE, IS NOW QUIESCENT.

Not unexpectedly to the naturalist, this range affords many endemic species of plants and animals, and those which range beyond its confines bear a more intimate relation with the forms inhabiting the mainland of Mexico and Arizona than to the remainder of peninsular California.

Hot springs and other manifestations of volcanic energy are to be found all along the geological vault on the eastern side of the peninsula of Baja California, but the most pronouncd feature of this character is to be found well out in the delta near Volcano Lake. Here on a saline plain a few miles in extent innumerable small mud cones, solfataras, and boiling pools of mud and water emit steam, smoke, and sulphurous gases, accompanied by a dull rumbling sound. According to the traditions of the Cucopa Indians, formerly a member of the tribe accused of sorcery or other serious crime was sent back to his evil master by the simple process of dropping him into a pool of boiling mud—an obvious entrance to his abode below. Flood-water covers a number of the small volcanoes, and then quite an extended area of the lake is agitated by the eruptions from below.

The largest of the volcanoes, known as the "Cerro Prieto," stands on the margin of the gravel slopes leading down from the main range of the Cucopa Mountains and rises as an irregular black mountain to a height of 750 feet, with several minor craters on its sides. The main crater is regular in form, and shows indications of activity at no remote time, although the bottom of the bowl now bears the characteristic vegetation of the desert, but including some species not now known elsewhere. In connection with the volcanoes are some boiling springs, which come to the surface a few feet above the level of the flood-water which flows from Volcano Lake into the Hardy. Immersed in the steaming water is a blue-green alga, which has been hitherto reported only from similar hot springs in Algeria, offering a problem in distribution the solution of which cannot even be conjectured.

The portion of the delta included in the Salton basin, which lies below sea level, and which is mostly within the State of California, is a true desert by means of its aridity and the saline character of the soil; consequently the plants and animals are referable to the Colorado desert, of which it in reality forms a part. The area actually irrigated by the river in normal low water and flood, however, is surrounded on all sides by desert and salt water, and is in reality a biological island. As such it offers an interesting comparison with the Cucopa Mountains, which limit it on the southwest, and which also constitute a sharply-defined life-area.

The quantity of food furnished by the swampy jungles is sufficient to support a vast amount of native animal life, and furnishes inviting feeding grounds for migrating birds. The countless millions of young willow and poplar shoots supply food for the beaver, which bids well to hold out long in the impassable bayous and swamps against its trapper foe.

The soil, climate, moisture, and temperature of the entire delta are fairly uniform, and also differ but little in elevation and exposure—a condition which tends to promote the multiplication of the number of individuals of a few species of plants, and these species are also able to maintain themselves in pure culture of some extent. An analysis of the vegetation of the delta confirms this view. Canes (*Phragmites*), cattails (*Typha*), willows (*Salix*), poplars (*Populus*) arrow-weed (*Pluchea sericea*), quelite (*Amaranthus Palmeri*), wild hemp (*Sesbania*), each occupy extensive areas, to the almost total exclusion of other seed-plants, although there are many places in which several of these will be found contending for the mastery. In all such areas of unstable equilibrium some change of the drainage, or of the action of the river, will be found as a disturbing cause.

Nearer the Gulf are found great sloughs, in which are extensive fields of the "wild rice" (*Uniola Palmeri*), while the land subject to the action of the overflow of the tides supports a carpet of salt-grass (*Distichlis*) and *Cressa.* Throughout the entire delta the mesquite (*Prosopis velutinea*) and the screwbean (*Prosopis pubescens*) dot the landscape, and furnish examples of one of the few components of the vegetation, the individuals of which grow singly and apart. The salt bush (*Atriplex*) also grows singly in great globular bunches overtopping the head of a man, on the lower stretches of saline soil.

In the enumeration of the following plants which have been found in various parts of the delta occasion is also taken to add notes as to known uses made of them by the Cucopa Indians:

Achronychia Cooperi A. Gray.

Saline soil near Volcano Lake.

Amaranthus Palmeri. Quelite.

Growing in open ground flooded at highest water. The young plants furnish forage for grazing animals, and are also eaten by the Indians. The mature plant reaches a height of 10 ft., and develops a crop of small shiny seeds, which are collected and stored for use as food.

Ammania latifolia L.

Along the Colorado on exposed banks.

Atriplex fasciculata S. Wats.

In saline soil near Volcano Lake.

Cressa Truxillensis H.B. K.

Mud-flats, forming extensive carpets with salt-grass in the southern part of the delta, in which the soil is slightly saline.

Cucurbita palmata.

Low ground throughout the delta.

Diplachne imbricata (Thurb).

Along the banks of the river and streamways.

Distichlis spicata (L.) Greene. Salt grass.

Forming carpet with Cressa in southern part of the delta, in which the soil is saline.

Echinochloa Crus-galli (L.).

Low ground near bayous and wet places. The seeds of this grass are probably to be included among those used for food.

Eclipta alba (L.). Hook.

Along the banks of the Rio Colorado near the margin of the stream.

Lippia cuneifolia (Torr.). Skud.

Exposed banks and bare places near the river.

Phragmites Phragmites. Cane, Carrizo, Tule.

Along the margins of streams, forming dense brakes. Used for making huts, flutes, and also in the construction of various articles.

Pluchea sericea (Nutt.). Coville. Arrow-weed.

In dense copses, forming pure cultures on banks above ordinary flood-level. Used by Cucopa Indians to form the shafts of arrows, to make the wattling and roofing of huts, for weaving coarse baskets, and granaries, etc.

Populus.

The young shoots are used, with willows, for wattling and portions of trunks for construction of huts.

Prosopis pubescens. Tornillo. Screw-bean.

Wood used in the same manner as the mesquite.

Prosopis velutinea. Mesquite.

The wood of the trunks is used for construction of all kinds, for making fires, and for tipping the points of arrows. The beans are collected and used for food.

Rumex sp. Dock.

Moist soil in open spaces.

Salix. Willow.

Two species are abundant throughout the delta, and these furnish material for use in huts, for the making of small hunting bows, and for miscellaneous purposes.

Scirpus fluviatilis A. Gray.

Mud flats throughout the delta.

Scirpus Californicus (C. A. Meyer). Britton.

Margins of streams.

Sesbania macrocarpa. Wild hemp. Wild flax.

Grows in open portions of the delta below flood-level, and sometimes reaches a height of 15 ft. The stems furnish a fibre which is used by the Indians for bow-strings and for other purposes as cords. Some attempts have been made to introduce this fibre into commerce.

Sesuvium sessile.

Along the shores of streams in the lower portion of the delta, in which the soil is moistened by water slightly saline or brackish.

Allenrolfia occidentalis.

Along the Santa Clara slough and other areas, in which the soil is saline.

Typha latifolia. Cat-tail tule.

Growing in level areas below flood-level and multiplying rapidly by means of offsets and forming pure cultures of great area. The underground stems, which are tender and succulent, are eaten by the wild hogs, while the sword-shaped leaves are used to pack the interstices of huts, and especially the small sweat-houses which are erected at the margins of lagoons. The great smokes which are seen almost constantly in the delta are mainly made by burning brakes of cat-tails for hunting purposes.

Uniola Palmeri. Wild rice.

Grows in the sloughs and wet places in the southern part of the delta, and the seeds are used as food by the Cucopa Indians.

At one time a herd of domestic hogs were turned loose in the tule swamps of the delta, and their progeny have reverted in so many features as to be as savage and untamable as their ancestors of a thousand years ago. Here, preying upon the hog and deer, is also to be found a "mountain lion," of a variety not found elsewhere, and even the widely-ranging coyote constitutes a species peculiar to the region, and quite at home in the mud of the swamps and bayous.

Surpassing in interest all other features of the delta is the Cucopa Indian, who inhabits it, and who is the heir and successor of many vanished tribes. First mentioned in the records of the expedition of Coronado in 1540 as seen to habitually carry fire-brands, which these old explorers naïvely thought was done for the purpose of keeping the hands warm, they were designated as the Tizon (firebrand) Indians, and the river received the same name. As a matter of fact, smouldering fagots were carried for the simple purpose of preserving fire and for its convenient use in burning the tules and canes to drive out animals hunted for food. At the beginning of the seventeenth century, Oñate descended the river to the mouth, and estimated that twenty thousand Indians were living in the eastern part of the delta alone, including various tribes, such as the Hatchedumas and Tlalliguamayas; but these, as well as the Quiquimas and Cutganes of the western part of the delta, have long since vanished from the region. Even as late as 1826 Hardy saw many thousands of Cucopas around the mouth of the Hardy; yet to-day the total population of the delta and the adjacent habitable part of the desert does not exceed three hundred. The only relics of the vanished hordes consist in hundreds of square miles of sandy plains strewn with fragments of coarse red pottery, and a prehistoric trail along the eastern foot of the Cucopa Mounains at the southwestern edge of the delta. For many miles the waters of the Hardy actually bathe the base of the rocky declivities, and along here the highway, as old as the race itself perhaps, is crowded into a narrow path. For untold cycles, until within a century, this trail must have been one of the most travelled of the southwest, since it led from the interior deserts and mountains to the wild rice fields and fishing grounds at the head of the Gulf, and was doubtless an inter-tribal highway of scarcely less importance than that along the Gila.

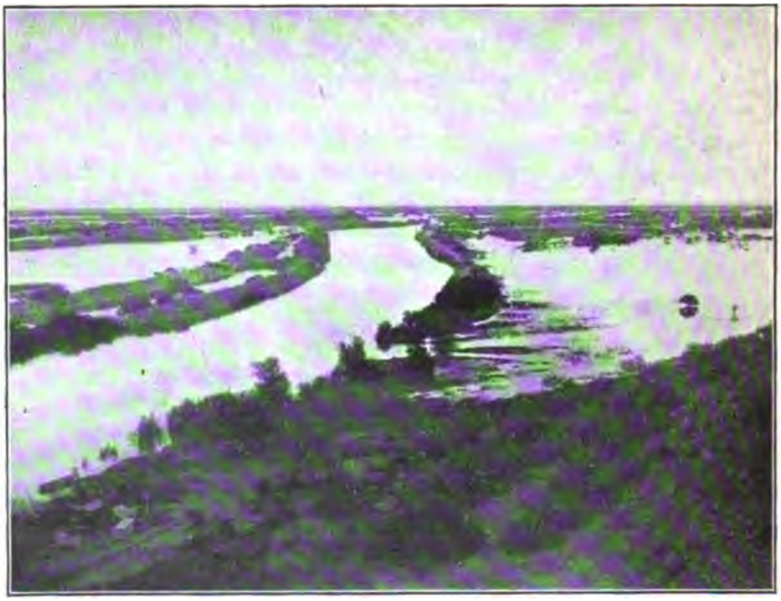


FIG. 6.—HARDY RIVER AT BASE OF CUCOPA MOUNTAINS. THE CHANNEL IS LINED WITH WILLOWS, CATTAILS, MESQUITE AND TULES. BETWEEN THE CAMP AND THE BASE OF THE SLOPE IS THE ANCIENT INDIAN TRAIL.

Within recent times the Cucopa Indians have been bested in a war with the Yumas at the head of the delta, but neither the losses suffered in this defeat nor traditions of other wars may account for this diminishing population. In the losing struggle carried on by this dwindling remnant, the deleterious effects of civilization have played but small part. Similar decreases of population in fertile river deltas are not unknown in other parts of the world. The native of the Colorado delta is a sturdy, well-built, peace-loving farmer of industrious habits by the standards prevailing in the land of the mañana, but he is notably lacking in handicraft or manual expertness of any kind. Living in a land cut and intersected in all directions by streams, he is neither a skilful boat-builder nor an expert canoeist, while the unaccountable tides and bores of the Gulf fill him with dread. The river teems with fish easily caught at times, and he lacks this food entirely when fishing becomes difficult. The tules swarm with game of many kinds, but the Cucopa is not a shrewd hunter. By the custom of his tribe all of his most necessary articles of personal use are burned or destroyed upon the death of a near relative, in consequence of which he does not weave textiles, make pottery, or build houses with enthusiasm or enduring effect, and is almost devoid of means of artistic expression of the symbols of his history or beliefs, and his diminishing numbers seem but an obvious illustration of the non-survival of the unfit.

The struggle for existence in the jungles of the warmer portions of the earth is one in which the human animal is often unsuccessful. The chief force against which he must contend is the rampant growth of vegetation, which impedes his agricultural efforts, and which makes all but impossible the breeding and preservation of domestic animals. Then in the protection of the jungle, wild animal life, from the most minute to the largest, multiplies with such rapidity as to constitute a hindrance to profitable effort, if not a formidable menace to health and bodily safety. Add to these the yearly summer inundation of the lands of the delta and the occasional flood of the winter, and conditions are created which may be met successfully only by the highly-organized methods of civilized society, and not by the intermittent, badly-directed individual effort of the aboriginal, who at best but holds his own in such a contest. With every pulsation of the summer heat the jungle closes a hardly measurable but positive accretion about his fields; with the loss of a working member of the family circle he handicaps himself to the limit of all he has previously gained, and when the creeping flood silently covers the land and drives him unprovided to the desert he must repeat the history of his race to regain his previous advantages.

With the initiation of the Yuma project for irrigation of the areas contiguous to the river in and around the head of the delta, a movement has begun which will make the alluvial lands a home of many thousands. The work of converting the delta to the uses of civilization will be hindered by the fact that some of the main drainage channels cross and then recross an international boundary; but doubtless in a comparatively brief period the agricultural aspect of the entire area will approach that of the Nile, which has supported a teeming population for centuries.

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The Incapacity of the Date Endosperm for Self-digestion

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The Incapacity of the Date Endosperm for Self-Digestion.

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INTRODUCTION.

THAT the digestion of nourishment stored in the endosperm is accomplished by the influence of enzymes which are secreted, or at least become active under conditions of germination, is universally accepted. The results and conclusions of various investigators are by no means uniform, as to whether or not the enzymes are developed in the embryo only or also in the endosperm independently of the embryo. The prevailing opinion, as recognized by Pfeffer, is that the endosperms of many grasses, palms, &c., possess a capacity for auto-digestion; that is, that such endosperms from which the embryos have been removed will, under optimum conditions of germination, provided digestion products may easily escape, digest themselves and become depleted of their storage substance. This view has become so widely accepted as no longer to be questioned.

When one examines the evidence upon which this conclusion rests he is surprised at its weakness. Moreover, associated with this view is a conception which is wholly out of date. The various authors have regarded as an almost self-evident fact that digestion by enzymes is evidence of vitality. The idea that a given tissue which happens to contain something capable of doing enzyme work is to be regarded as living matter, is no longer modern.

This paper is intended to show, first: that the literature as it stands does not furnish convincing proof of auto-digestion by endosperms, and second, that the date endosperm which Puriewitsch found to be capable of auto-depletion, and which he regards as living matter, does not possess such capacity.

The weakness of the evidence as presented by various authors is in nearly every case to be explained by unreliable data. For instance, the seeds have been allowed to germinate before removing the embryo when

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it is well known that the latter contains enzyme. Some have based conclusions on the fact that the 'culture fluid' reduced Fehling's solution. The latter is of no significance unless it be known that reducing substances are not already present in the endosperm.

It is of course essential to understand what constitutes auto-depletion. The mere diffusion of soluble cell-substance from the tissue cannot be regarded as such. There must be evidence of chemical change, such as corrosion of starch-grains or dissolution of cell-wall. That the storage organs in some seeds are the cotyledons must not be overlooked, and the distinction must always be made between the behaviour of fleshy embryos and endosperms.

HISTORICAL.

Gris ('64, p. 90), in a notable contribution to the anatomy and physiology of germination, mentions some changes which were observed in the cell contents (aleurone especially) during germination, but Van Tieghem was the first to attack the problem directly. Van Tieghem ('77, p. 582) found that isolated endosperms of *Ricinus communis* under germination respire and are self-digesting, since the aleurone and oil are consumed, while the endosperms of *Canna* (amylaceous) and date (horny) are 'passive' and remain unchanged. He clearly implies that endosperms rich in oil and aleurone are self-digesting and possess vitality, while starchy endosperms and those containing reserve cellulose are not self-digesting and do not possess vitality. This conclusion rests purely on microscopical observations, and while the changes observed in *Ricinus* do indicate self-digestion, the possibility of a feeble digestion by the date is not excluded by such observations. So far as I am aware, this conclusion of Van Tieghem's regarding *Ricinus* has never been questioned.

Green ('90, p. 146) investigated the germination of *Ricinus communis* and found a 'ferment to exist as zymogen in the resting seed which is readily developed by warmth and weak acids into an active condition.' As to the relative influence of the endosperm and embryo he found 'the changes to be initiated in the endosperm, for they take place, although more slowly when the embryo is carefully removed.' The changes referred to consist (Green, '90, p. 147) in the saponification of fat into glycerine and ricinoleic acid especially, also the formation of sugar. Unfortunately the details of this work are not sufficient to permit any judgement as to the degree of demonstration attained.

Green ('86, p. 57) made glycerine extracts of the cotyledons of date-seedlings and of the endosperm-residue. Both extracts were applied to ground endosperms of resting date-seeds, but neither gave evidence of hydrolytic activity. We do not know what evidence was searched for, as the author merely states that, 'after prolonged action neither of them (extracts) seemed to have had any effect, at least the quantity of ground cellulose had not apparently diminished.' However, another portion of the cotyledon extract was found by Fehling's test to have formed reducing sugar by its action on manufactured cotton fibre, while a similar portion boiled to destroy the enzyme was found to have no action on cotton fibre. From these results, and an examination of the cotyledon-structure, Green concludes that the ferment exists only in the epidermal cells of the cotyledon, and since the endosperm extract seemed to yield no sugar after contact with the ground resting endosperms, he finally says regarding the endosperm, 'there was no evidence that the extract of the endosperm had any action on cellulose at all. Evidently in it there is no ferment and the change is due to agencies quite external to its cells.'

Brown and Morris, after an extended study of the barley endosperm, agreed with Van Tieghem that the amylaceous endosperm of the grasses is a 'dead store house' of reserve material. In the same paper ('90, p. 480) the possibility is left open that the aleurone layer may contain some residual vitality, but the starch-bearing cells do not, and the conclusion including the 'dead store house' applies only to these starch-grain-cells. They further found ('90, p. 525) that the diastatic capacity of scutellum-cells is destroyed by treatment with vapour of chloroform. But when 'portions of the integuments of germinating barley, with their adherent aleurone layer, are treated in a similar way with chloroform vapour, we have found that their diastatic power *is not in the least impaired*, the starch under such sections being as quickly and completely attacked as under sections which have not been treated. Moreover, we have observed the same thing even after the fragments have been immersed for some time in absolute alcohol.' These authors assume that such treatment must have destroyed vitality, yet they acknowledge that the diastatic capacity remains undiminished. If then diastatic activity can proceed in dead tissue, how did these authors conclude that the amylaceous tissue of the endosperm constitutes a 'dead store house' because it does not possess diastatic activity? The inference of course is, that if such cells had been found able to do enzyme work they would have been regarded as living. As a matter of fact, their conclusion is that the aleurone cells are living because they show diastatic activity, and yet this activity was manifested under conditions which must have prohibited vitality. This affords an excellent example of the trouble which arises when vitality and enzyme activity are confused. It must be said here that these authors probably do not hold such views at the present time, but in a review of this kind it is necessary to deal with the literature as it stands. They further find ('90, p. 509) that translocation diastase is probably produced in the endosperm-cells by the embryo during its ante-resting development and that residual translocation diastase constitutes the diastase of the resting grain. It may be said in this connexion that no one has proved that the diastase of the resting grain is in the endosperm as well as in the embryo. They do show ('90, p. 507) that during formation of the seed the diastase increases. The proportion of diastase was estimated at three stages, namely: endosperm about one half developed, endosperm about two-thirds developed, endosperm fully developed but not ripe. This does not show, however, as stated by Green ('01, p. 18), that the increase of enzyme takes place in the endosperm unless we assume that during the early development the embryo is too small to be considered. Brown and Morris do not state that they estimated the diastase present in the endosperm, but that they estimated the diastase in the grain when the endosperm was in varying stages of maturity. In this connexion they also state that a similar quantity of mature ungerminated grains yielded a similar quantity of cupric oxide. In this later test, however, the ungerminated seeds were allowed to steep, just how long is not stated, nor at what temperature, but if as long as in a preceding experiment (p. 496) the steeping lasted 24 hours and the temperature was not high enough to kill the embryo. Even if the steeping were only twenty-four hours the possibility of enzyme passing from the embryo to the endosperm is open[1]. On p. 507, they show that the major part of the soluble enzyme in the resting seed (after steeping) is located in the proximal half (embryo half), and that some also exists in the distal half. If it were not for the steeping a demonstration of enzyme in this distal half would be conceded. This paper of Brown and Morris may then be summarized as attributing diastatic capacity and vitality to the aleurone cells but as denying both to the amylaceous endosperm.

Grüss ('93, p. 288) found evidence of enzyme activity in the endosperm of maize from seedlings whose hypocotyls had elongated to six or seven centimeters. Since the aleurone layer and scutellum contain a much greater quantity of enzyme, he concluded that the diastase is secreted by these tissues and by diffusion from them penetrates the endosperm. Later, Grüss ('96, p. 439) found that isolated endosperms of maize under sterile conditions of germination for twelve days gave a very positive reaction with the guaiac-hydrogen-peroxide test. A similar result was obtained with the endosperm of barley. If this guaiac test is to be accepted as reliable we must regard the capacity of the endosperms of maize and barley to generate enzyme independently of the embryo as demonstrated. To support this by further evidence the direct sugar test was made with Fehling's solution. In this case, the barley endosperms were in moist sand four days, but no statement is made that sterile conditions were maintained. The glycerine extract from these endosperms after digestion for eighteen hours with 1 per cent. starch-paste and diluted gave a mixed solution 5 cc. of which reduced 1·8 cc. of Fehling's solution. A similar solution from normally germinated seeds reduced 1·9 cc., while such a solution from ungerminated seeds reduced 1·1 cc. This experiment is not conclusive, for the following reasons:—It is not positively stated or implied that the endosperms remained sterile; the starch-paste may have contained a little sugar; the digestion during eighteen hours may not have been free from the influence of organisms, as no statement of such precaution is made; ten hours is the limit of safety without antiseptics at 37° C.; the end reaction with Fehling's solution is not accurate to even 1 cc. with mixed solutions containing proteid and starch in varying stages of alteration; the small differences of ·1 cc. between the reducing power of the solution from isolated endosperms and of the solution from normally germinated seeds is suspicious. Moreover, if the endosperm contains reducing substance an extract from material soaked four days would probably contain more of such reducing substance than a similar extract from dry resting endosperms even though the time of extraction in both cases were equal.

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[1] Brown and Escombe ('98, p. 11) concede the possibility of enzyme from the embryo penetrating the endosperm during steeping, and say that the embryo should be removed while the seed is still dry.

In the case of the date-seed, Grüss ('96, p. 421) found the resting endosperm to be practically free from enzyme by the guaiac-hydrogen-peroxide test. In the endosperm of germinating seedlings ('96, p. 422) he found by test isolated blue spots indicating the local generation of enzyme independently of the embryo. But concerning this it may be said that as long as the cotyledon was present during germination such a test cannot be regarded as demonstrating independent activity by the endosperm. In summarizing the work of Grüss we may say that the autolysis of the endosperm in the cases of barley and maize is proven only in so far as the guaiac-hydrogen-peroxide test is specified for the presence of hydrolizing enzymes. In the case of the date there is little approach to convincing evidence.

Hansteen ('94, p. 426) regards Van Tieghem's conclusion, concerning self-digestion as occurring in oily seeds but not in amylaceous seeds, as untenable. First, because Van Tieghem made no provision for the escape of the products of digestion. The accumulation of such products in starchy seeds would soon inhibit further digestion. Such inhibition in the case of oily seeds would, however, occur much later, because the oil is first changed to transitory starch and considerable disappearance of oil might be noted before the accumulation of the products of starch transformation would inhibit further digestion. Second, because Hansteen considers himself to have demonstrated that isolated endosperms of barley and corn under sterile conditions of germination favourable to the escape of digestion-products are self-digesting to a considerable extent, and that actual depletion and corrosion of the grains may be noted. The surrounding water into which the digestion-products diffuse becomes reducing to Fehling's solution. The only objection to Hansteen's tests are, first: that he allowed the grains to soak for two days before removing the embryo, so that the possibility of the diffusion of enzyme from embryo to endosperm is open. That this is a valid objection is recognized by Brown and Escombe ('98, p. 11). On the other hand, Pfeffer ('97, p. 612) regards Hansteen's experiments as demonstrating the capacity of corn and barley endosperms for auto-depletion. Second, he does not show that the endosperm does not already contain some reducing sugar, which, if present, could easily diffuse into the surrounding water.

Linz ('96, p. 311) has shown that in isolated endosperms of maize under conditions of germination a marked increase in sugar content occurs during a period of twelve days. But since he allowed the grains to soak for two days before removing the embryos it is impossible to attribute this increase of sugar exclusively to the activity of enzymes in the endosperm. He draws the unqualified conclusion that the endosperm is living matter. A similar objection may be taken to Linz's ('96, p. 318) unwarranted conclusion that in such endosperms it is not the aleurone layer which furnishes the enzyme. He merely found that after two days' soaking the aleurone layer contains less enzyme that the endosperm, which may mean that during the two days' soaking enough enzyme diffused from the aleurone layer to establish the relative distribution he found. Brown and Escombe found that the aleurone layer (barley) only contains enzyme, and that the corrosion of starch is more notable in the tissue contiguous to it. Moreover, this observation disagrees with that of Grüss ('93, p. 288) who found the aleurone layer and scutellum to contain a much greater quantity of enzyme than the endosperm in the case of seedlings whose hypocotyls had elongated six or seven centimeters.

Leclerc du Sablon ('97, p. 395) made analyses of the date-seed before and after germination. He found oil and sugar to be present in the resting endosperm, together with some little aleurone intermixed with the protoplasm. The sugar is present in only about 1 per cent., and is to be regarded as a saccharose, since it reduces Fehling's solution with precision only after boiling with acid. The carbohydrates insoluble in 90 per cent. alcohol, but soluble in water, are present in only about 2 per cent. Determinations of the amount of sugar present in the resting endosperm were made, and also in the endosperm during germination, when the radicle had elongated to various lengths. His results show a constant increase in the sugar content of the endosperm, but he regards the increase as insignificant, and concludes that the date endosperm is incapable of self-digestion. Examination of his data reveals that he found 0·019 grms. of sugar in a quantity of endosperm tissue when the radicle measured 0·50 cms., and when the radicle measured 4·0 cms. he found 0·024 grms. which is an increase of 26 per cent. Such an increase would be significant if occurring in the endosperm under conditions which would permit us to say that the embryo had no influence. Sablon notes the interesting fact that during germination the relative quantity of oil in the undigested portion of the endosperm remains about constant, 7 to 9 per cent. He also finds that the sugar and dextrin also remain about constant, but that the resting grain contains a little more because it has not lost by exosmosis. He concludes that the enzyme from the embryo does not penetrate the endosperm.

Puriewitsch ('97, p. 13) studied the depletion of the date endosperm, and concluded that it is capable of auto-digestion. How such a conclusion could be drawn from the data he has recorded cannot be understood. In the first place he allowed the seeds to germinate in sand until the radicle was from 3–7 cms. long. This would require, according to temperature, from two to four weeks, and enzyme from the embryo would certainly pass into the endosperm. Newcombe ('99, p. 68) found an enzyme in the endosperm during later germination, and if my own conclusion is correct, that an enzyme cannot be detected in the resting endosperm, it is evident that such diffusion must occur during germination [1]. Moreover, Puriewitsch does not record actual evidence of digestion. He found merely that the 'culture fluid' was reducing to Fehling's solution. This is not significant, because the resting endosperm contains reducing substance, and further the tannin present would give the same reaction. As a matter of fact his record furnishes more evidence for a negative conclusion, because in microscopic sections of his material he did not find any notable difference between test objects and controls. How could auto-digestion be attributed to a tissue which, after thirty-six days at 27° C., showed no evidence of dissolution as compared with controls? Further he regards the endosperm as living matter capable of initiating and continuing vital processes ('97, p. 16).

In '98, after the researches of Hansteen and Puriewitsch, which are regarded by Pfeffer ('97, p. 613) as demonstrating that the endosperms of barley, maize, and date are capable of self-digestion, Brown and Escombe ('98, pp. 3–24) undertook a reinvestigation of the work of Brown and Morris ('90, p. 458). After quoting the general conclusions of the latter as follows: 'Although the peripheral layer of the endosperm, the so-called aleurone-layer, undoubtedly consists of living cells, no evidence could be obtained of the existence of any residual vitality in the amyliferous cells which constitute by far the greater portion of the endosperm,' they state that there is a general agreement in the work of Hansteen, Pfeffer, Grüss, and Puriewitsch that the amyliferous cells of the endosperm of the grasses have a definite power of digesting their reserve materials, this power being entirely independent of any influence of the embryo, the only necessary condition for its exhibition being that the products of metabolism shall not be allowed to accumulate within the endosperm.

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[1] Puriewitsch makes a brief statement which shows that this source of error was not overlooked, but he does not show that the error was actually avoided. His statement seems to refer to the cereal endosperms especially, and cannot be applied to the date, because in the text descriptive of manipulation in the date experiments he states that the seeds were allowed to germinate.

As a result of this reinvestigation Brown and Escombe ('98, p. 14) have demonstrated a hydrolytic capacity of the aleurone cells of barley. Degermed endosperms steeped in saturated aqueous chloroform twenty-four hours show no depletion for several days, until invaded by organisms, while others not chloroformed show marked sub-aleuronic depletion and dissolution of starch grains. Cytological study of aleurone cells shows a 'well defined nucleus and all the usual cytological evidence of activity,' and these cells are commonly regarded as living units. They also find ('98, p. 18), from a cytological study of the amyliferous cells (barley), that the latter are in a very different condition from that of the aleurone cells. The nucleus is deformed, and the general structure indicates senescence. Actual trial showed the amyliferous cells to be without digestive capacity. Endosperms without embryos or aleurone, under favourable conditions for germination and removal of metabolic products, showed no difference as compared with similar ones treated with saturated aqueous chloroform for twenty-four hours. No visible changes occurred in either case until appearance of organisms, when visible changes did occur, so that it is possible, though rather improbable, that changes might have occurred later if the organisms had been kept out. This work of Brown and Escombe may, then, be regarded as demonstrating the capacity of the aleurone layer of barley for endosperm depletion and as rendering such capacity on the part of the amyliferous cells highly improbable.

The literature thus examined shows that auto-digestion by the amylaceous endosperms of grasses or by the horny endosperms of palms has not been successfully demonstrated, although such a claim has been made by different authors, and this claim has been accepted hitherto. On the other hand, the presence of an enzyme in the aleurone cells of barley has been demonstrated, and Puriewitsch has made reasonably certain a similar statement for other cereals. The question of the vitality of either aleurone cells or of endosperm cells is quite open, for the simple reason that actual vitality tests have not been applied. The work of Brown and Escombe above cited indicates, but does not demonstrate, that the aleurone cells are living, and that the amyliferous cells are not.

INVESTIGATION.

Material and its preparation.—By applying to a large wholesale candy house I was able to secure a large quantity of seeds without buying the fruit. There is a further advantage in that such firms get the best and freshest, so that seeds saved from such fruit are large and nearly all capable of germination. The seeds so obtained are partially cleaned, but it is always necessary to wash them thoroughly without soaking, after which they may be stored in a dry place for use as needed. The fleshy mesocarp contains reducing sugar.

In all the material used embryo substance was absolutely excluded. This was accomplished by rotating the point of a pocket-knife in the embryo cavity of each and every dry seed until, by examination, all traces of embryo substance were removed. In all the material used this task was done by myself. Since the membranaceous endocarp which still clings to the seeds as so far cleaned contains tannin, it is necessary to remove this in some way. This may be accomplished either by sifting over an air blast after each grinding, and before the powder becomes at all fine, or by washing and drying rapidly after each time through the mill. By either method so little tannin remains that digestion in water at ordinary temperature for six hours gives a liquid which does not react with ferric chloride. Both methods were used: the former before it was known that the contained proteids are insoluble in water, and the latter after.

Estimation of the hydrolytic product.—Having found Fehling's solution unsuitable for my purpose, I decided to find a method which would give me more reliable data. Since starch, dextrine, and enzyme are insoluble in 95 per cent. alcohol, while the reducing sugars arising from enzyme activity are soluble, this reagent was employed for separation. The following test shows the efficiency of such a method. A solution of soluble starch[1] was made, and its content of anhydrous starch per cubic centimeter determined by evaporating over steam triplicate volumes, drying the residue at 110° C. for one hour, cooling in the desiccator and weighing. The anhydrous content of a filtered solution of amylopsin was similarly determined. It was thus possible to titrate a given weight of starch with a given weight of enzyme, and then to determine the weight of the hydrolytic product as follows: After digestion the solutions were made 95 per cent. alcoholic and then allowed to stand until the precipitate settled. The alcoholic solution was decanted, filtered, the precipitate washed with alcohol and the filtrate then evaporated to dryness over steam in tared beakers. The residue was air-dried at 110° C. to constant weight. This residue is brown, with a sweetish, toast-like odour, very hygroscopic, easily soluble in water, and reduces Fehling's solution, but the reaction is not precise, and much of the precipitate remains in suspension for some time, but finally settles. From the following tables it is evident that the hydrolytic product soluble in alcohol is very constant for a given ratio of enzyme to starch.

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[1] Dry potato starch was extracted with glycerine (180°-190° C.) for thirty minutes and precipitated with alcohol. Purification was accomplished by reprecipitation with alcohol from aqueous solution.

All the figures represent anhydrous weight in grams. Three ratios of enzyme to starch were tried in duplicate. The starch solution contained in 1 cc. 0·01625. The enzyme solution contained in 1 cc. 0·00160. Titration closer than ·1 cc. not attempted.

	Enzyme.	Starch.	Hydrolytic Product.
1 : 100	No. 1—0·004960	0·500	0·4700
	No. 2—0·004960	0·500	0·4700
1 : 200	No. 1—0·002560	0·500	0·4870
	No. 2—0·002560	0·500	0·4950
1 : 300	No. 1—0·00160	0·500	0·4180
	No. 2—0·00160	0·500	0·4150

These figures show that a reasonably accurate determination of hydrolytic product can be made with varying dilutions of enzyme. Such a determination is far more satisfactory than the usual colour method with iodine. The enzyme used was advertised to convert into dextrine and maltose 250 times its own weight of starch in three hours at about 40° C. The fact that the hydrolytic product for the ratio 1 : 200 is greater than that for the ratio 1 : 100 is to be attributed to difference in digestion conditions, since no attempt at comparison was made except for the duplicates of a given ratio. As dextrine is known to be one of the products of enzyme activity, since dextrine is insoluble in 95 per cent. alcohol, it is evidently excluded in this method. Since the ratio of the hydrolytic product thus obtained is so constant for a given ratio of enzyme to starch, it must be regarded as a very convenient and accurate method for testing the hydrolytic capacity of a given enzyme.

In applying this method to the study of the Date it was found necessary to evaporate to dryness and then extract with alcohol instead of depending upon the alcohol to precipitate all unhydrolized matter. This evaporation must continue until the residue is hard. If to the viscous residue alcohol be added, some of the carbohydrates, though insoluble in alcohol, mix with it and when heated an apparently clear solution is obtained. The alcoholic extract should cool to room temperature before filtering. Failure to observe these precautions gave me results from which a conclusion contrary to the one here given was published[1].

During extraction with alcohol the beakers were covered with watch crystals thus making a sort of reflux condenser.

Properties of the aqueous extract.—The powdered endosperm (400 grms.) prepared as described above yields, after about six hours' digestion with distilled water (1,200 cc.), a liquid which when filtered has the following properties. It is neutral to litmus and remains neutral until by putrefaction it becomes acid. It does not contain tannin, as the test with ferric chloride was negative. It does not contain coagulable proteid, for on boiling with acetic acid in several dilutions no flocculation occurred. Care was taken to acidify after boiling and not before. On standing twenty-four hours after boiling there was so sediment. Prompt disappearance of turbidity on acidification suggested the presence of phosphates (tribasic calcium phosphate). On testing with molybdic solution a fine yellow precipitate fell promptly, and on standing twenty-four hours an abundant yellow sediment settled (ammonic-phospho-molybdate). The extract, in contact with concentrated nitric acid, failed to give even the slightest turbidity at junction or anywhere, which suggested the absence of all forms of proteid matter except perhaps secondary proteoses and peptones. The xanthroproteic reaction is doubtful, because the extract has a faintly yellow colour and a slight opalescence. The colour, slight as it is, turns to orange with alkali (NaOH and NH_4OH), and similar change occurs with concentrated nitric acid, the colour in the latter case deepening on addition of alkali. Reversing the order of addition reverses the effects, or if heat is generated other colours, such as brown or reddish-brown, are produced. The colouring matter does not react sharply however. The same tests with commercial tannin did not give identical results, although various colourations were obtained. Dilute alkali causes the change of colour but dilute acid does not. The opalescence is, however, destroyed by both reagents. Glacial acetic acid does not produce visible change. Mineral acids, however, if concentrated, seem to have decided positive effect.

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[1] Pond, '04, p. 181.

Negative results were obtained in the following tests for proteids: Mayer's reagent, Millon's reagent, acetic acid and potassium ferrocyanide, and boiling in an acidified, saturated solution of ammonium sulphate. The latter solution, after filtering, was negative in the Biuret test. The latter reaction and the xanthroproteic test are not reliable with the extract because the colour produced by the alkali or strong acid obscures any evidence of change.

The extract reduces Fehling's solution if not too much reagent is used. If some freshly prepared reagent is diluted and boiled, and then the extract be added slowly, a prompt reduction occurs very soon. If the reagent is present in excess the reduction may not occur. In some cases I noted a heavy flocculation without reduction. This flocculation was found to be produced by the copper sulphate alone. On removing the precipitate the filtrate was promptly reducing. That this reduction was not due to tannin is certain because the test with ferric chloride was negative.

The reaction with phenylhydrazin is positive. Carbohydrates insoluble in alcohol are present, and they may be fractionally precipitated with different strengths of alcohol, but very little precipitation occurs after a concentration of 80 per cent. is reached. The substance precipitated by alcohol when dried is of a dirty white colour and partially soluble in water. It does not respond to any of the tests for proteids. This behaviour excludes albumins and globulins, and adds emphasis to the negative tests with the extract itself. These observations do not agree with those of Puriewitsch ('97, p. 66) who obtained flocculation on boiling his 'culture fluid' with acetic acid, and a white precipitate with acetic acid and potassium ferrocyanide. Either his observations were faulty or else some coagulable proteid passed from the embryo to the endosperm during germination.

Extraction with sodium chloride. The same powder, after the preceding extraction with water, was digested with 5 per cent. sodium chloride for sixty hours (toluol, 5 per cent.). This extract was neutral to litmus. On heating, a milky turbidity appeared which was more opaque than was that of the aqueous extract. The heating was continued to boiling for a minute, when a flocculent precipitate appeared which redissolved on cooling and reappeared on heating. The turbidity was destroyed by acetic acid and did not reappear until the acidity was neutralized by ammonium hydroxide. Other reactions agreed with those of the aqueous extract, except that a white precipitate formed with acetic acid and potassium ferrocyanide. This latter result was found to be due to impurities in the toluol, as the acetic acid alone with the toluol gave the white precipitate. The flocculation on boiling was found to be due to impurities in the sodium chloride. This leaves the sodium chloride extract negative in all tests for proteids, just as was the aqueous extract, and positive for phosphates. The sodium chloride itself did not react for phosphates with molybdic solution.

Extraction with sodium hydroxide, ·1 per cent. The residue remaining after the extraction with sodium chloride was digested sixty hours with sodium hydroxide, ·1 per cent. and toluol, 5 per cent. The filtered extract was found to be only slightly alkaline so that the alkalinity had evidently decreased during the digestion. This extract does not have the opalescent hue of the other extracts but instead is of a deep amber colour. This colour is undoubtedly due to the alkali, as it appeared almost instantly when the latter was added. As the neutral point was slowly approached with acetic acid the amber gradually disappeared, being replaced slowly by a dirty opalescence. As the reaction became faintly acid a cloud was noticed, which gradually spread through the liquid as the reaction became distinctly acid. On standing a few minutes this turbidity developed to a flocculation and a curdy precipitate finally settled.

This precipitate changed to brick red on boiling with Millon's reagent. The filtrate did not react with any reagents for proteids nor with ammonium sulphate. The extract itself did not respond to any of the proteid tests except with ammonium sulphate. The latter test was positive because the small amount of proteid present was concentrated into a precipitate. Coagulation did not occur when the extract was boiled at the neutral point.

Another extract was made from fresh dry powder. After two hours digestion the brownish red extract gave a precipitate at the neutral point. Continuing the extraction over night (sixteen hours), the extract did not give a precipitate at the neutral point, and boiling at the neutral point was without apparent effect. When slightly but distinctly acid the precipitate settled.

Extraction with sodium hydroxide, 2 per cent. The residue remaining after the extraction with sodium hydroxide, ·1 per cent., was exhausted sixty hours with a 2 per cent. solution of the same reagent. The powder immediately turned a dark blood red with a brownish tinge. The filtered extract was of course alkaline. On close neutralization with acetic acid no change occurred, not even after boiling. Continuing the acidification slowly, no change was apparent when a decided acid reaction was attained, but continuing still farther the brownish tinge gradually disappeared, and when strongly acid a change to cherry red occurred, and a copious flocculent precipitate settled. This result made it clear that a fairly large amount of proteid can be extracted with a proper strength of alkali. The ·1 per cent. alkali is evidently too weak to extract all the proteid. Since the 2 per cent. alkali, however, might have effected some decomposition of the proteid, it seemed best to try a moderate strength.

Extraction with sodium hydroxide, ·5 per cent. On adding 500 cc. of ·5 per cent. NaOH solution to 500 grms. of freshly prepared powder the usual change to brownish red occurred. After forty-eight hours it was noticed that this colour had disappeared, and the reaction was found to be acid to litmus[1]. The same volume of alkali solution was then added and the brownish red colour returned and remained for sixty hours. On acidification with acetic acid the filtered extract yielded a copious flocculent precipitate. The latter, after fusing with caustic potash, gave an unusually abundant yellow precipitate of ammonic-phospho-molybdate. This result, in connexion with the data already recorded, may be accepted as evidence of the presence of considerable nucleoproteid. The wet precipitate resembles the extract in colour, being perhaps more brown than red. No colour was imparted to any of the following reagents on stirring the still wet precipitate into them: aceton, methyl alcohol, ethyl alcohol, benzol, petroleum ether, turpentine and carbon bisulphide. Some of the matter which colours the precipitate is soluble in hot water, and this solution gave a weak reaction for tannin with ferric chloride[2].

Why this extract became acid after forty-eight hours while the ·1 per cent. extract was still alkaline after sixty hours is not known. The two cases are not comparable, however, because one was with fresh powder and the other with material which had been successively exhausted with water and sodium chloride.

[2] The remainder of the precipitate was studied further by Dr. Gies, as far as the quantity would permit, and the following observations were made by him. After drying at room temperature and being reduced to a powder, which was dark red, the precipitate was redissolved in dilute alkali

Demonstration of tannin in the endocarp. The thin membranous endocarp may be obtained in quantity as a chaff by sifting the powder, especially after the first time through the mill. On boiling some of this endocarp chaff in water, a light brown solution was obtained, which gave with ferric chloride a brown precipitate and a brownish green filtrate. By using a more dilute solution of the reagent a typical blue green colour without a precipitate was obtained, On adding lead acetate a grey precipitate fell leaving a water clear filtrate. Potassium ferrocyanide caused a grey precipitate to fall. Iodine gave a reddish brown precipitate.

A cold aqueous extract of the endocarp chaff gave a typical reduction of Fehling's solution, probably due to the reducing sugar held by the membranes. Another portion of chaff, after being washed until an hour's aqueous extract at ordinary temperature did not reduce Fehling's solution, was extracted with boiling water. This extract reduced Fehling's solution, presumably because of the tannin rather than because of sugar. That tannin was present was made certain by the test with ferric chloride. Further, this extract gave the same colour reaction with alkali as the powdered endosperm from which the tannin was not obtained after long digestion in cold water. The endosperm substance entirely freed from endocarp substance by scraping the dry seed does not develop this colour with alkali. Thus it seems probable that the endosperm powder prepared as previously described above contains so little tannin or associated substances that not enough goes into solution in cold water to react with ferric chloride, but that enough is present to produce the change noted when alkali is added.

Recapitulation of preceding data. The facts of special interest now revealed are: the endosperm contains reducing sugar, the endocarp contains tannin, the only proteid present in significant amount is the nucleoproteid.

Experiment No. 1. Is the aqueous extract of the resting endosperm auto-hydrolytic? For this test 400 grms. of powdered endosperm were

(KOH, 2 per cent.) and reprecipitated by slight acidification with dilute acetic acid. This process was conducted three times. The filtrates were amber coloured. The final precipitate seemed as deeply coloured as the first. The filtrates were free from phosphate. The precipitate contained phosphorus. On digestion in pepsin-hydrochloric-acid (2 per cent. each), a slight residue resembling the original precipitate remained, containing phosphorus. It was soluble in dilute alkali and appeared to be a nuclein or a mixture containing it. Hydrated with 2 per cent. HCL a deep red solution was formed, and a brownish black, flocculent material collected. The latter was slowly soluble in dilute alkali and, after being reprecipitated with acid, the colour remained the same and no effort was made to determine the nature of the latter. The filtrate was made strongly alkaline with NH_4OH. Treatment with an excess of ammoniacal silver solution had no effect. There was no precipitate of silver-purin compounds after standing twenty-four hours. These observations indicate that the original precipitate is not a pure substance. It contains not only nucleoproteid but apparently the colouring matter already noted. It is possible also that other substances or compounds of nucleoproteids are present, and further study with more material would be necessary to establish definite conclusions.

used. This quantity of powder was digested fifteen hours in the refrigerator (12° C.) in 1500 cc. of tap-water which had been filtered through a Berkefeld filter. No antiseptics were used, the low temperature sufficing to inhibit putrefaction, as was shown by the neutral reaction of the filtered extract. The test for tannin in the filtered extract was negative, so 75 cc. of it were delivered from pipette into each of four beakers. Two of these beakers, group 1, were immediately evaporated to dryness over steam. The remaining pair, group 2, were digested eight days at 35° C. During this period a strength of 5 per cent. toluol was maintained. The beakers were covered with a watch crystal and stirred daily. After evaporating to dryness the duplicates of group 2, all four beakers were then extracted with 95 per cent. alcohol by boiling for three hours. After cooling and decanting over night, the alcoholic extracts were filtered into four tared beakers and evaporated to dryness over steam. The residues thus obtained were dried to constant weight at 120° C. and being very hygroscopic were cooled in the desiccator and weighed as rapidly as possible. The duplicates of group 1 were respectively ·5765 grm. and ·5805 grm., while those of group 2 were ·5465 grm. and ·5610 grm. Evidently the quantity of monoses in solution did not increase and hydrolysis could not have occurred. Since the aqueous extract contains non-reducing carbohydrates, which are converted into reducing sugars by the action of dilute acids, no reason is apparent why hydrolysis should not have taken place, if any enzyme were present, unless it might be that the non-reducing carbohydrates were present in sufficient amount to inhibit any enzyme action. That this was not the cause of the negative result seems clear from the results of subsequent experiments. That the temperature of digestion was favourable must be assumed because the seed germinates much more rapidly at this temperature than at lower ones.

Experiment No. 2. Is the endosperm powder capable of auto-digestion? Into each of four beakers 25 grms. of powdered endosperm were placed. The weighing itself was accurate, but no attempt to get the actual weight of the powder was made, the moisture remaining after three days' exposure to room temperature after grinding being included. Into each of two of these beakers 75 cc. of 1 per cent. $CuSO_4$ were delivered from pipette, and into each of the remaining two were placed 75 cc. of 1 per cent toluol. All four beakers were incubated ten days at 35° C., being stirred daily and the toluol renewed. On the tenth day the liquor from each beaker was filtered, and into four tared beakers 50 cc. of each filtrate were respectively placed. The anhydrous alcohol soluble residues were: toluol, ·4326 grm. and ·4110 grm.; copper sulphate, ·4400 grm. and ·4647 grm. The latter residues were coloured by the copper sulphate and no doubt a small amount of the latter was dissolved by the alcohol, but this would not affect more than the second decimal place. The figures certainly indicate a negative result, and the only possible objection is that mentioned in the preceding experiment, namely, the inhibition of enzyme activity by the presence of substances in solution.

Experiment No. 3. Does an enzyme develop in the endosperm during germination? In experiment number 1, the aqueous extract was from the resting endosperm. In experiment number 2, the endosperm substance was under conditions comparable to those of germination, except that aerobic respiration was impossible and the escape of any hydrolytic products could not proceed normally. So it seemed best to test the behaviour of endosperms which had been under conditions favourable for germination. For this purpose a quantity of degermed but otherwise whole endosperms was divided into two groups. The individuals of group 1 were located on a perforated, floating board so that each rested in a thin film of water. The volume of water which floated the board was about twenty litres and this was renewed daily. The endosperms were kept sterile by washing them for three minutes daily in a one per cent. solution of copper sulphate. The germination of a few seeds whose embryos were intentionally left undisturbed was not prevented by this treatment. That is, of course, the radicles protruded. The individuals of group 2, intended as controls, were placed in crystallizing dishes and enough one per cent. copper sulphate solution added to about one half submerge them. This solution was renewed every three days, so as to make the loss by diffusion comparable with that occurring in group 1. After twenty-eight days at room temperature, the endosperms were ground and the tannin removed as usual. With the powder thus obtained a repetition of experiment number 2 was made, except that the residue from 25 cc. of filtrate was determined instead of from 50 cc. The residues of group 1 were ·1310 and ·1360 grm. Those from group 2 were ·1835 and ·1883 grm. Evidently there is no more manifestation of enzyme in this experiment than in the preceding ones. The possibility of the same disturbing factor was not excluded, however, although its potency would necessarily be reduced by the loss of substance from the endosperm during the period under conditions of germination.

The residues are less than one half those found in the preceding experiment. This would be expected, as sugar originally present was lost by diffusion during the twenty-eight days under germination conditions. In both cases the copper sulphate residues are larger, and since by calculation from the solubility of copper sulphate in alcohol, it may easily be seen that not all of the difference can be attributed to this, it seems quite probable that the escape of sugar from the endosperm proceeds more slowly in the copper sulphate solution. This granted, the result is just what would be expected as a consequence of simple exomose in the absence of enzyme.

Experiment No. 4. Do degermed but otherwise whole endosperms show any internal corrosion or evidence of auto-digestion after a long period under optimum conditions of germination? While preceding tests render a negative answer highly probable, the following experiment was made as a conclusive test. Twenty degermed and carefully cleaned endosperms were placed in a vertical position behind a rubber band which encircled a small crystallizing dish. The preparation was then placed in a dish containing sufficient 1 per cent. toluol to leave the endosperms standing about one-fourth submerged. Diffusion and escape of hydrolytic products were thus well provided for and respiration was not interfered with. The preparation was then kept in the incubator at 35° C. for fifty-six days. A control preparation in 1 per cent. copper sulphate was carried. The solutions of these preparations were, with few exceptions renewed daily. The toluol of this strength is such a weak antiseptic that a daily renewal is necessary as also the bathing of the unsubmerged portions of the endosperms. Seeds will commence germination under these conditions.

At the conclusion of the test period the endosperms were sectioned, stained in Bismarck brown and mounted in glycerine. After clearing over night microscopic examination failed to reveal the slightest evidence of auto-digestion. The walls were intact. No such corrosion markings as figured by Grüss ('94a, taf. 14 and 15) could be found. Comparison was made with dry resting endosperms but no positive difference could be detected. The middle lamella showed very plainly in all three sets of sections, but no difference either in cell wall or cell contents could be noted.

Conclusion:—The endosperm of *Phoenix dactylifera* is incapable of self-digestion.

While this investigation has been continued intermittently for some years, the major part of the results here recorded have been obtained during my incumbency of a research scholarship, June, July, and August, 1905, in the New York Botanical Garden. I am especially indebted to Professor Wm. J. Gies, consulting chemist of the Garden, and to Dr. D. T. MacDougal, assistant director, for advice and facilities in carrying out the work.

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CONTRIBUTION FROM THE NEW YORK BOTANICAL GARDEN—No. 79

AFFINITIES OF CERTAIN CRETACEOUS PLANT REMAINS COMMONLY REFERRED TO THE *GENERA* DAMMARA AND BRACHYPHYLLUM

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AFFINITIES OF CERTAIN CRETACEOUS PLANT REMAINS COMMONLY REFERRED TO THE GENERA DAMMARA AND BRACHYPHYLLUM[1]

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INTRODUCTION

THIS paper is a preliminary contribution, designed to demonstrate the value of critical examinations of palæobotanical material by means of the microscope. The results obtained by such examinations of three kinds of Cretaceous fossil plant remains are described, *viz.*: cone scales commonly referred to the living genus Dammara, leafy branches commonly referred to the extinct Coniferous genus Brachyphyllum, whose exact botanical affinities have not heretofore been satisfactorily determined, and certain lignitic fragments found associated with the foregoing.

The first mentioned are shown to belong not to Dammara but to an extinct genus, closely related to it, to which the new generic name Protodammara is given. The second are shown to be Araucarinean in their affinities and probably to represent the branches of the tree which bore the cones from which the scales of Protodammara were derived. The third are shown to be referable to Araucarioxylon and probably to represent the wood of the tree which bore the leaves of Brachyphyllum and the cones of Protodammara.

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Contributions from the New York Botanical Garden.— No. 79.

DISCOVERIES WHICH SUGGESTED THE PREPARATION OF THIS PAPER

The discoveries which suggested the preparation of this paper were described in a previous paper read before the Botanical Society of America at the Philadelphia meeting, on December 30th, 1904.[1] During the autumn of that year an interesting section of Cretaceous deposits was found exposed in the Androvette clay pit, at Kreischerville, Staten Island, N. Y. At this locality the deposits consist of irregularly stratified sands and clays, in one part of which occurs a lens-shaped bed of closely packed vegetable *débris*, consisting of leaves, cone scales, twigs, amber, charred wood, and lignite. At that time special attention was given to the amber and the other remains were merely examined superficially and briefly mentioned. The suggestion was made by Dr. Jeffrey that critical examination of the lignitic fragments would probably produce interesting results, and this suggestion led to two joint visits to Kreischerville during the past year and the collection of a large amount of new material, in part from the original locality and the remainder from the nearby Drummond pit. Some of the results obtained from the examination of this material form the basis of this contribution.

OBJECT AND SCOPE OF THE INVESTIGATION

One of the great difficulties in connection with any attempt to determine satisfactorily the relationships of palæobotanical specimens is due to the fact that such specimens are nearly always more or less fragmentary, being represented only by dismembered parts or organs of plants, and seldom or never by a complete individual organism. Under such conditions it is not surprising that descriptions based upon superficial characters only have frequently resulted in erroneous generic determinations; different parts of the same species have often been described under two or more specific or generic names; or occasionally a single specific name was made to include several different fragments which were subsequently ascertained to belong to two or more distinct species.

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[1] Arthur Hollick. "The Occurrence and Origin of Amber in the Eastern United States." Published in *Amer. Nat.*, vol. 29, pp. 137–145, *pls. 1–3*, 1905.

The identification or determination of a genus solely from the shape or superficial markings of a cone or some of its detached scales or of a leaf or a leafy twig, can seldom be entirely conclusive or satisfactory; but it may be readily appreciated that if, in addition, the internal structure of such specimens can be made out by the use of the microscope, not only may the genera be thus determined beyond question, but many fragmentary scattered remains, presenting no superficial characters of any diagnostic value, might thus be identified and brought together into their true generic and specific relationships.

Superficial examination of the Kreischerville material showed that it contained a number of recognized species, descriptions of which were based upon well defined external characters, besides quantities of specimens which were not identifiable by ordinary means. This indicated a specially favorable field for investigation, of which advantage was taken, and the methods employed, together with some of the selected results obtained, are here described.

Description of the Gross Material

Botanical Characters of the Plant Remains.— A rough examination of the gross material showed the presence of pteridophytes, angiosperms, and gymnosperms. The remains of the pteridophytes were exceedingly fragmentary and unsatisfactory. Those of the angiosperms consisted for the most part of dicotyledonous leaf impressions in the clay, usually accompanied by a thin film of carbonaceous matter, which generally disappeared on exposure to the air.

The remains of the gymnosperms proved to be more satisfactory, however, being represented not only by isolated coniferous leaves which retained more or less of the substance of the plant, but also by leafy twigs and branches, cones and cone scales, and fragments and logs of lignite, some of which contained amber in their interstices. Special attention was therefore given to these remains amongst which specimens of the following genera and species were separated out and identified.

List of the Coniferous Remains

1. Cone scales, allied to Dammara and similar to very small specimens of *D. microlepis* Heer. These are described in this paper on p. 199 under the new generic name Protodammara.
2. Cone scales and leaves of *Pinus* sp. The scales are relatively small. Several of the leaf specimens showed three in a bundle, enclosed in a sheath.
3. Leafy twigs of *Sequoia reichenbachi* (Gein.) Heer, *S. heterophylla* Vel., *Juniperus hypnoides* Heer, *Widdringtonites reichii* (Etts.) Heer, *Frenelopsis gracilis* Newb., and *Brachyphyllum macrocarpum* Newb.
4. Lignite and other fragmentary coniferous remains which could not be generically determined from their external characters.
5. Amber, occasionally in the interstices of the lignites, but for the most part in the form of small drops or "tears" and irregular fragments.

METHODS EMPLOYED IN THE CRITICAL EXAMINATION OF THE MATERIAL

Maceration and Separation of the Gross Material.—In the examination of the finer vegetable *débris* previously described the following method was employed. Caustic soda or potash in 1 to 3% solution was used with considerable success. After this treatment the fragments of plants were somewhat swollen and separated readily from one another and from the argillaceous matrix. The loosened clay was washed away on a wire gauze tray of not too fine meshwork and the lignitic or carbonaceous fragments were left in a clean and recognizable condition. The fragments in most cases were rather small, especially those of greatest interest, so that the most convenient method of recognition was by means of a dissecting microscope of very low magnification. A great many different kinds of coniferous remains were thus separated out and identified from their external appearance, as well as many charred specimens of dicotyledonous woods. Of these in general no account will be given at the present time, for attention was restricted to the cone scales similar to those referred by Heer to the genus Dammara, leafy branches belonging to the Brongniartian genus Brachyphyllum, and certain Araucarineous lignites. The chosen material was often in a very good state of preservation especially when charred, or partially charred.

Sectioning and Microscopic Examination of Specimens.—In the case of lignitic or charred vegetable remains it is necessary for successful study to obtain very thin sections, on account of the dark color and opacity of the fossilized tissues. By the use of hydrofluoric acid for removing mineral matter and by embedding in thickened celloidin, it was found possible to make sections often of large area, as thin as 5 micra which proved admirable for photomicrographic purposes. These sections were cleared at once in benzole without previous staining, since the natural dark color of the lignites was sufficiently pronounced to differentiate the structures, even in very thin sections. In some cases it was found necessary to reduce the natural dark hue of the preparations and chlorine water was useful for this purpose. The sections were mounted in balsam on plate-glass slides and after previous drying were subjected to pressure and high temperature in the warm oven for the purpose of making them perfectly flat. All the photomicrographs in the present article were made by means of Zeiss lenses, except those showing surface features. The latter were executed with the admirable Heliar lenses of the Spencer Lens Co. Electric light was employed in all cases as the illuminant.

DESCRIPTIONS OF SPECIMENS

Cone Scales Commonly Referred to Dammara. —Fossil cone scales similar to ours were described and figured for the first time by Professor Edward Hitchcock,[1] in his account of the organic remains found at Gay Head, Martha's Vineyard. They were not named by him, but his figures and description leave little to be desired. He says: "Figs. 4, and 5, represent different individuals of another variety of vegetable remains. . . . These are not mere impressions; but a scale of carbonaceous matter, mixed with amber, marks the spot where the vegetable was imprisoned. . . . It seems to me very obvious that these remains must be the seed vessels of some coniferous plants."

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[1] *Final Rept. Geol. Mass.*, vol. 2, p. 430, *pl. 19, figs. 4, 5*, 1841.

It was not until many years after Hitchcock's description was published that any further discovery of similar remains was made, or at least recorded, and to Professor Oswald Heer belongs the credit of first recognizing their affinities with the living Coniferous genus Dammara, in his description of specimens identical with those from Gay Head, under the name *D. borealis*,[1] from the Cretaceous of Greenland, in his discussion of which he says (p. 55): "Es haben diese Schuppen so grosse Aehnlichkeit mit derjenigen von Dammara (Agathis), dass wir sie derselben Gattung zutheilen dürfen." For purposes of comparison a figure of this species, representing a specimen collected at Gay Head, is shown on Plate 1, Fig. 1.

Two other so called species were also described and figured by the same author, *viz.*: *D. microlepis*[2] and *D. macrosperma*.[3] A specimen of the former, collected at the Gay Head locality, is shown on Plate 1, Fig. 2, which, by comparison, may be seen to differ from *D. borealis* merely in size. *D. macrosperma* has not been recognized in any collection of material except that from Greenland, and it is doubtful if it should be regarded as specifically distinct from the other two. In other words all three of these so called species might very well be included under *D. borealis*.

Heer was evidently in considerable doubt in regard to the identity of some of his specimens and also with regard to their botanical relationships. In his discussion of *D. microlepis* for example he says (p. 55, *loc. cit.*): "Hat einige Aehnlichkeit mit den Blüthenknospen des Eucalyptus Geinitzi," and a comparison with the figures of the objects which he refers to the fruit of that species[4] shows them to be so closely similar in appearance to his Dammara scales as to be practically indistinguishable from them.

Krasser, Beyer, and Velenovsky subsequently described and figured similar remains from the Cretaceous of Europe, with varying opinions as to their probable botanical affinities. The last author first referred them to *Eucalyptus geinitzi* Heer,[1] with the leaves of which species they were found closely associated, but later he called what are evidently identical remains *Dammara borealis* Heer.[2]

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[1] *Fl. Foss. Arct.*, vol. 6, pt. 2, p. 54, *pl. 37*, *fig. 5*, 1882.

[2] *Ibid.*, p. 55, *pl. 40*, *fig. 5*.

[3] *Ibid.*, vol. 7, p. 17, *pl. 53*, *fig. 11*, 1883.

[4] *Ibid.*, vol. 6, pt. 2, p. 93, *pl. 45*, *figs. 4–9*, 1882.

In 1889, Mr. David White visited Gay Head, and in the following year, in a paper "On Cretaceous Plants from Martha's Vineyard"[3] he described and figured specimens collected there, referring to them as follows (pp. 98, 99): "Next to the preceding species, the most numerous of the plants from Gay Head is *Eucalyptus Geinitzi* Hr., fig. 8–11, two of whose fruits, 'resembling unopened flowers of syngenesian plants,' were figured as 'scales of vegetable remains' in Hitchcock's Final Report. This species, first described from the Liriodendron beds (Middle Cretaceous) of Greenland, is abundant in and most characteristic of the Middle Cretaceous of Bohemia, and is also present in the same stage (Cenomanian) in Moravia. The specimen, fig. 11, is included here on account of its coincidence with one figured by Velenovsky (Foss. Flor. böhm. Kreide., iv, pl. xxv, fig. 7), which he supposed represented a flower of this species. It may belong to a conifer.

"The remains of the nuts show longitudinal furrows (white in the figures) filled with a resin which is 'indistinguishable by ordinary tests from Amber,' and which was observed and pronounced amber by Hitchcock in 1841. These doubtless are the remains of gum or oil vessels, such as exist in the nuts of recent Eucalypts; and the granules of 'amber' can hardly be else than Eucalyptus gum.

"The explanation is at once suggested that the fragments of amber observed by various writers, during the last hundred years, about Gay Head, and in the New Jersey Cretaceous, where also Eucalypts are found, are the product of the contemporaneous 'gum-trees,' rather than of some conifer. None of this American amber has, I believe, been tested for succinic acid, or to show its relation to true amber."

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[1] *Foss. Fl. Böhm. Kreideform.*, pt. 4, p. 1 [62], *pl. 1* [*24*], *figs. 1, 2; pl. 2* [*25*], *figs. 6–11; pl. 4* [*27*], *fig. 13 in part*, 1885.

[2] *Kvet. Cesk. Cenomanu*, p. 7, *pl. 1*, *figs. 28, 29*, 1889.

[3] *Amer. Journ. Sci.*, vol. 39, p. 93–101, *pl. 2*, 1890.

At about this same time Dr. J. S. Newberry was engaged in the investigation of the Cretaceous flora of New Jersey, the results o which were later included in his "Flora of the Amboy Clays."[1] In this work he lists *Dammara borealis* Heer as a characteristic and abundant element of the flora, and says (pp. 46, 47): "In his Flora Fossilis Arctica (loc. cit.) Professor Heer describes and figures the scales of a conifer which very much resemble those of *Dammara australis,* and yet there are some reasons for doubting the accuracy of his reference. It may also be said that the fruit scales which he calls *Eucalyptus Geinitzi*.... are without doubt generically the same.... the fruits figured by Heer under the name of Eucalyptus are plainly scales, and are parts of an imbricated cone. I say this with confidence, because it has happened that in the Amboy clays we have found numbers of them sometimes associated together, oftener scattered and showing both faces. A peculiarity of these scales is that they are striped longitudinally by clefts which are filled with an amber-like substance. This structure is plainly seen in those figured by Professor Heer on Pl. XLV. Similar scales are described in an article by Mr. David White on the fossil plants from Gay Head....

"The considerations which have led me to doubt whether these cone scales are those of Dammara are that we have found no Dammara-like leaves associated with them, whereas in New Jersey they occur in great numbers mingled with and sometimes apparently attached to the branchlets of an extremely delicate conifer much like Heer's *Juniperus macilenta*.... Almost no other plant except this conifer is found with the cone scales, and it is difficult to avoid the conclusion that they belong together. Another reason for doubting whether these are the scales of a Dammara is that in some of them traces of two seeds are apparently visible, while in Dammara there is but one seed under each scale."[2]

The discussion is further continued by Dr. Newberry under his description of *Juniperus macilenta,* on pp. 54, 55 (*loc. cit.*), as follows: "Thickly scattered among the twigs there are cone scales and cones . . . . The cone scales are evidently identical with those described by Heer under the name of *Dammara microlepis*. . . . and probably with those described by him as *Dammara borealis.*" He says, however, that they cannot belong either to *Dammara* or to *Juniperus* and finally concludes with the hope "that in the future material will be obtained that will enable us to reconstruct this tree and determine with accuracy its botanical relations."

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[1] *Monogr. U. S. Geol. Surv.*, vol. 26, 1895.

[2] This observation by Dr. Newberry is particularly interesting in the light of what we now know in regard to the Kreischerville specimens, as may be appreciated by referring to our description of the seed scars on those scales, on p. 199.

Dr. Newberry again refers to the scales in connection with his discussion of *Eucalyptus? angustifolia,* in the following words (*ibid.*, p. 111): "Professor Heer feels strengthened in his reference of leaves having this nervation to Eucalyptus by finding in company with them what he regards as the fruit of Eucalyptus; but in my judgment the examples he gives of this fruit. . . . are rather detached scales of the cone of some conifer, and probably generically identical with the cone scales which he has called *Dammara borealis.*"

Some years ago the senior writer of this paper began an investigation of the Cretaceous flora of the Atlantic coastal plain, and in the material collected in New Jersey and on Staten Island, Long Island, Block Island, and Martha's Vineyard, numerous specimens of cone scales were found, some of them unquestionably identical with *Dammara borealis* or *D. microlepis* as defined by Heer, and others which apparently represented new species. Following are references to the specimens in question:—

"*Dammara borealis,* Heer?" Tottenville, Staten Island. *Trans. N. Y. Acad. Sci.*, vol. 12, p. 31, *pl. 1, fig. 17,* 1892.

"*Dammara borealis,* Heer." Chappaquidick, Martha's Vineyard. *Bull. N. Y. Bot. Gard.*, vol. 2, p. 402, *pl. 41, fig. 6,* 1902.

"*Dammara microlepis* Heer (?)." Ball's Point, Block Island. *Ann. N. Y. Acad. Sci.*, vol. 11, p. 57, *pl. 3, figs. 9 a, b,* 1898. At the time when these two specimens were described they were only referred provisionally to this species, in the following words: "The ones under consideration are, however, smaller than any which have been previously figured and might perhaps be referred to a new species, but in view of the limited amount of material and its fragmentary condition, I have thought it best to refer the specimens provisionally to Heer's species." I am now satisfied that they belong to the new genus and species hereafter described and they are included, for comparison, on Plate 1, Figs. 12, 13.

"*Dammara Northportensis* sp. nov." Little Neck, Northport Harbor, Long Island. *Bull. N. Y. Bot. Gard.*, vol. 3, p. 405, *pl. 70, figs. 1, 2,* 1904. A figure of this species is reproduced on Plate 1, Fig. 4.

"*Dammara (?) Cliffwoodensis* n. sp." Cliffwood, N. J. *Trans. N. Y. Acad. Sci.*, vol. 16, p. 128, *pl. 11, figs. 5–8,* 1897. A figure of the type specimen of this species is reproduced on Plate 1, Fig. 3. This species may also be found described and figured by Mr. Edward W. Berry in his "Flora of the Matawan Formation (Crosswick's Clays),"[1] and again in a subsequent paper on "Additions to the Flora of the Matawan Formation";[2] but the figures more nearly resemble *D. borealis* than they do the species to which they are referred, and the author himself remarks, in regard to the one last mentioned (p. 70): "The specimen is an unusually perfect one.... In outline and size it is very similar to the scale from Tottenville referred by Hollick to *Dammara borealis* Heer."

Finally may be mentioned the species described and figured by Dr. F. H. Knowlton, under the name *Dammara acicularis*, in his "Fossil Plants of the Judith River Beds,"[3] which differs from all the other species in the possession of a well defined apical awn or spine, although in many of our individual specimens a similar feature, of smaller size, is present, and in others its former presence is clearly indicated.

If all the opinions expressed by the authors in the papers quoted, are analyzed it may be seen that a majority favor the idea that the scales are Coniferous and that their relationships are with *Dammara,* or with some other genus closely allied to it. Whether more than one species is represented in the various forms that have been described as such is a problem which yet remains to be solved and its solution will doubtless be attended with more or less difficulty, but the identification of the genus to which each form belongs should be a comparatively easy task, provided the material available for study is such that it can be sectioned and subjected to critical examination under the microscope. Thus far the only specimens which we have so examined are those from Kreischerville, but it is hoped that the investigation may be continued in the future so as to include specimens from other localities.

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[1] *Bull. N. Y. Bot. Gard.*, vol. 3, p. 61, *pl. 48, figs. 8–11,* 1903.

[2] *Bull. Torrey Bot. Club*, vol. 31, p. 69, *pl. 1, fig. 11,* 1904.

[3] *Bull. U. S. Geol. Surv.*, no. 257, p. 134, *pl. 15, figs. 2–5,* 1905.

Protodammara speciosa n. gen. et sp.

Plate 1, Figs. 5–13; Plate 2, Figs. 1–5

"*Dammara microlepis* Heer (?)." Hollick, *Ann. N. Y. Acad. Sci.*, vol. 11, p. 57, *pl.* 3, *figs.* 9 *a*, *b*, 1898.

Organisms consisting of kite-shaped cone scales, from 4 to 6 mm. long by 4 to 6 mm. broad above, abruptly narrowed from about the middle to the base, rounded, incurved, and apiculate above; resin ducts five or more, extending down the lower surface of the limb; seed scars three in number, crescentically arranged above the middle and approximately in the broadest part of the scale, with the central one higher up than the laterals.

Plate 1, Figs. 5–13, shows the scales natural size; Plate 2, Figs. 1 a, b, c, 2, shows four specimens with the upper surfaces exposed, magnified about ten diameters. Although they may be seen to resemble closely those of a small female cone of Dammara they are distinguished from the scales of that genus by the apical process and by the fact that they obviously bore three seeds instead of only one. It might indeed be inferred, from the presence of three apically attached ovules, that we have here to do with cone scales of one of the Sequoiineæ, rather than with one of the Araucarineæ, but the internal structure shows that they are truly Araucarian.

Plate 2, Fig. 3, represents a transverse section of the base of a scale, magnified about 40 times. A little below the middle point may be seen a single small fibrovascular bundle. At a higher plane of section this separates off a single upper bundle of inverted orientation and gives off a number of lateral bundles to the lower surface of the scale. The upper bundle supplies the seeds. In the higher part of the scale the inferior bundles are surrounded by a dense cordon of transfusion tissue. The arrangement of the bundles of the scale presents throughout a close resemblance to that found in Dammara.

Plate 2, Fig. 4, represents about half of a transverse section of a scale, magnified about 50 times. The funicular attachment of one of the lateral seeds may be seen on the upper surface of the scale.

Plate 2, Fig. 5, shows a longitudinal section through the apex of the scale, which at the same time is also nearly median, magnified about 40 times.

There can be no doubt that these scales are Araucarian and that while they resemble the genus Dammara they do not belong to it. We have therefore proposed for them the generic appellation Protodammara.

Formation and Locality: Cretaceous clays, Raritan Formation. Pl. 1, Figs. 5–11 and Pl. 2, Figs. 1 a, b, c, 2, Kreischerville, Staten Island, N. Y.; Pl. 1, Figs. 12, 13, Ball's Point, Block Island, R. I.

Leafy Branches Commonly Referred to Brachyphyllum.—This genus was based upon the external characters of certain leafy branches, of Jurassic age, and was described under the noncommittal heading "Conifère douteuse." The type of the genus is *B. mamillare* Brongt., which he described but did not figure.[1] The species was figured by subsequent authorities however, notably by Saporta,[2] one of whose illustrations (fig. 4, *loc. cit.*), is reproduced on Plate 1, Fig. 14. A number of other species have also been described under the genus and under the closely related or synonymous genera Echinostrobus, Arthrotaxites, Thuites, Palæocyparis, etc. By some authors these genera have been all included under Brachyphyllum and by others they have either been regarded as distinct or else they have been grouped in various combinations. Their true botanical relationships, however, were never satisfactorily determined, although they were generally considered as allied to the Sequoiineæ or the Cupressineæ and as related to Arthrotaxis, Thuja, or Glyptostrobus. The species described by the earlier authors were all from Jurassic horizons but subsequently species were described from the Cretaceous,[1] and it is with these that we are especially concerned.

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[1] *Prod. Hist. Veg. Foss.*, p. 109, 1828.

[2] *Plantes Jurassiques*, vol. 3, *pl. 34, figs. 3–7*, 1884.

The question of generic identity between the several allied forms does not, however, come within the scope of this paper. The only matter which is of immediate concern is the fact that we have found at Kreischerville the leafy branches of a Brachyphyllum and have been able to determine, for the first time, by means of its internal structure, the exact relationship which it bears to certain living Coniferæ. This species is the same so far as external characters are concerned, as that described by Newberry from the Amboy clays of New Jersey (*B. macrocarpum* Newb., *loc. cit.*), and it has also been found at Northport, Long Island, and at Cliffwood, N. J. A reproduction of Newberry's fig. 1 (*loc. cit.*) is shown on Plate 1, Fig. 15, and the Northport specimens on the same plate, Figs. 16, 17. These are all natural size.

Plate 3, Figs. 1 a, b, c, shows three fragments of branches from Kreischerville, magnified about 6 times, and Fig. 2, on the same plate, shows one magnified about 10 times.

Plate 3, Fig. 3, shows a piece of another branch magnified about the same as the latter, and illustrates particularly well the longitudinal converging striæ characteristic of the leaves of Brachyphyllum.

Plate 3, Fig. 4, represents a transverse section through a relatively old branch, magnified by 8, in which the woody cylinder is well developed. The pith has largely collapsed, although it consists in large part of sclerotic cells.

Plate 3, Fig. 5, shows a transverse section of a young branch, magnified by 15. Four leaves may be seen on the margins of the figure, and of these, those on the broad upper and lower surfaces of the branch overlap those on the margins, as they are cut through at a higher region. The leaves are attached to the surface of the stem by practically all of their ventral surface, with only a very narrow border left free, where in their upper portions they overlap their neighbors. The anatomical features cannot be made out in this section as the magnification is not sufficient.

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[1] *Echinostrobus squamosus* Vel., *Gymnosp. Böhm. Kreideform.*, p. 16, *pl. 6, figs. 3, 6–8*, 1885; *Thuites crassus* Lesq., *Cret. and Tert. Fl.*, p. 32, 1883; *Brachyphyllum macrocarpum* Newb., "Fl. Amboy Clays" (*Monogr. U. S. Geol. Surv.*, vol. 26), p. 51, footnote, *pl. 7, figs. 1, 2, 5, 7*, 1895.

Plate 4, Fig. 1, shows a transverse section through the woody cylinder of the younger branch shown on Plate 3, Fig. 5. By using a lens it may be seen that at this stage the cylinder consists of clearly separated bundles. On the right a single leaf-trace is passing off.

Plate 4, Fig. 2, reproduces a cross section of the basal portion of a leaf from the margin of the same young branch. It may be seen that there are several fibrovascular bundles present. These have originated from the single trace previously described. Of the Cupressineæ, Sequoiineæ, and Araucarineæ, the only Conifers with which Brachyphyllum has ever been placed, *the latter group alone have the branched leaf-trace.*

Plate 4, Fig. 3, shows a similarly branching leaf-trace from one of the broad leaves which clothe the upper and lower surfaces of the stem in the genus Brachyphyllum.

Plate 4, Fig. 4, shows a portion of the latter under a higher degree of magnification. The lower fibrovascular tissue is obviously dividing into three branches.

Plate 4, Fig. 5, is part of a branch of Brachyphyllum in transverse section. The light spaces are the sections of resin-canals. Although the material was passed through a number of solvents of resin, used in a hot condition, there is still some matter present in the lumina of the resin-passages. This appears to be of a mucilaginous nature *and is comparable to that found among living Conifers only in the genera Araucaria and Dammara.*

Plate 4, Fig. 6, shows a transverse section of a diseased branch of Brachyphyllum, in which there is one particularly large resin-cavity. The fossil mucilage, as we consider it to be, is present also in this instance. We have, in fact, found this substance to be always present in Brachyphyllum, except in charred branches, and those which had become very rotten in the process of fossilization. *The mucilaginous contents of the resin-canals afford another reason for associating Brachyphyllum with the Araucarineæ rather than with the Cupressineæ or the Sequoiineæ.*

The most important argument, however, in favor of the Araucarineous nature of Brachyphyllum is the structure of the wood and phloëm. Plate 5, Fig. 1, is a longitudinal radial section of the tracheids of the wood, highly magnified. *They show the flattened and alternating bordered pits, which are the diagnostic feature of Araucarioxylon Kraus.*

Plate 5, Fig. 2, makes the diagnosis beyond dispute, as *it shows the very striking Araucarineous character of the rays.* Plate 5, Fig. 3, represents a transverse section through the xylem and phloëm in a yearling branch. Plate 5, Fig. 4, shows two bundles in the young stem of Brachyphyllum. It may be seen that *the region of the phloëm is marked by the absence of the regularly alternating rows of hard bast-fibers, which are found without exception in the phloëm of all Cupressineous and Sequoiineous Conifers.*

Lignites Referable to Araucarioxylon.— Associated with the cone scales of Protodammara and with the leafy branches of Brachyphyllum are found numerous specimens of lignite, amongst which are two types of Araucarioxylon. The first of these is very similar to the wood of the living Dammara, and like Dammara it is characterized by the presence of resinous tracheids. The pith, when present, is seen to be large and composed mainly of tanniniferous cells as in that genus. When wounded the wood of this Araucarioxylon does not give rise to traumatic resin-canals.

The second type, so far as we have been able to observe, does not possess resinous tracheids. The pith, when present, is sclerified and of small size as in Brachyphyllum. The wood, when injured, forms resin-canals of a traumatic character.

Plate 5, Fig. 5, shows a row of traumatic resin-canals in this species. Plate 5, Fig. 6, shows one of these resin-canals and the adjacent wood, highly magnified. The tracheids of the wood are seen to be free from resin. *This type of Araucarioxylon appears to be the wood of Brachyphyllum,* while the type first described appears to belong to Araucarian Conifers more nearly allied in structure to those now in existence.

CONCLUSIONS

The cone-scales referred by Heër to Dammara, at least in the case of those from Kreischerville, do not belong to that genus but to the hitherto unrecognized Araucarinean genus Protodammara.

The leafy shoots and branches from several eastern American Cretaceous beds referred by various authors to Brachyphyllum[1] are of Araucarian affinities, as shown by their structure and as indicated by their constant association with the cone scales of Protodammara.

A large part of the lignites associated with both the above are Araucarineous and probably represent in part the wood of the trees which bore the leafy branches of Brachyphyllum and the cones of Protodammara.

The latter genus was in all probability the last survivor of an ancient Araucarian line of descent, joined near its base with the primitive stocks of the Abietineous and Cupressineous series. Its anatomical characters show that it was forced to occupy less advantageous situations in Cretaceous times, and possibly in earlier periods as well. It may have grown on dry hills, while the better adapted related forms, which still survive in the modern genera Araucaria and Dammara, flourished in the richer lowlands, in company with other gymnosperms of higher type of development and with the angiosperms, which even then had begun to assume the predominant position which they occupy to-day.

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[1] We do not consider it by any means proved, that all the leafy branches of the type of Brachyphyllum are necessarily Araucarian. It appears not improbable that some of the shoots of this general type may belong to other families of the Conifers. This for example may well be the case with some Coniferous remains recently described by M. Zeiller, from the upper Lias of Madagascar and referred to Sequoiineous affinities. In this instance the cones were found attached to the branches and the author remarks that the superior portion of the cone scale terminates "en une pointe obtusement aigue", a somewhat suspicious feature of resemblance to our Protodammara.

PLATE 1

FIG. 1.— *Dammara borealis* Heer, natural size. Gay Head, Martha's Vineyard, Mass.

FIG. 2.— *Dammara microlepis* Heer, natural size. Gay Head, Martha's Vineyard, Mass.

FIG. 3.— *Dammara cliffwoodensis* Hollick, natural size. Cliffwood, N. J.

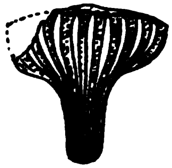
FIG. 4.— *Dammara northportensis* Hollick, natural size. Little Neck, Northport Harbor, Long Island, N. Y.

FIGS. 5–13.— *Protodammara speciosa* n. gen. et sp., natural size. Figs. 5–11, Kreischerville, Staten Island, N. Y.; Figs. 12, 13, Ball's Point, Block Island, R. I.

FIG. 14.— *Brachyphyllum mamillare* Brongt. (after Saporta), natural size.

FIG. 15.— *Brachyphyllum macrocarpum* Newb., natural size. South Amboy, N. J.

FIGS. 16, 17.— *Brachyphyllum macrocarpum* Newb., natural size. Little Neck, Northport Harbor, Long Island, N. Y.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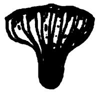
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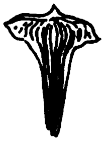
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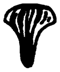
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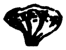
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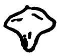
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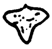
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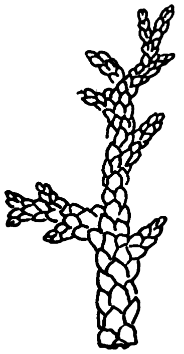
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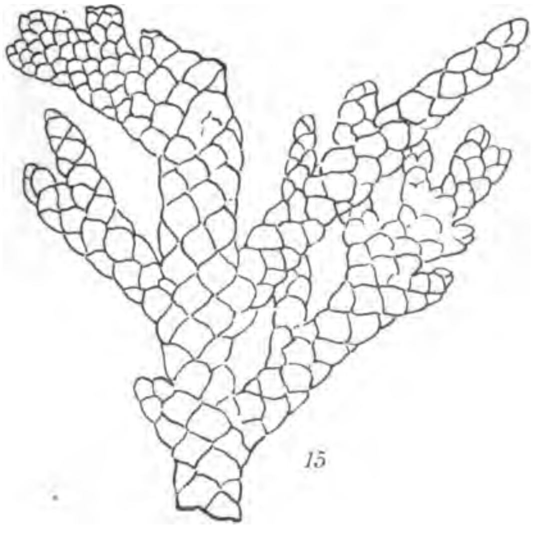
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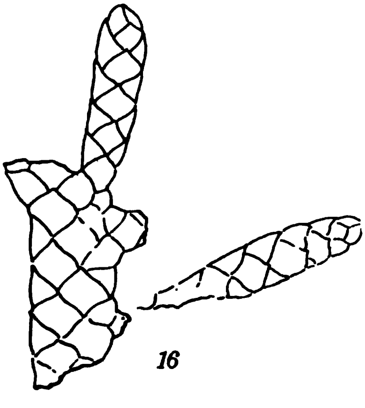
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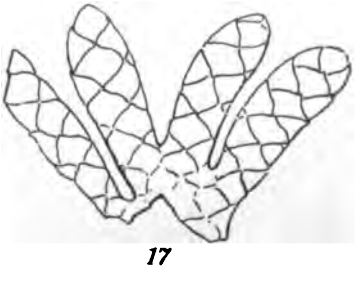
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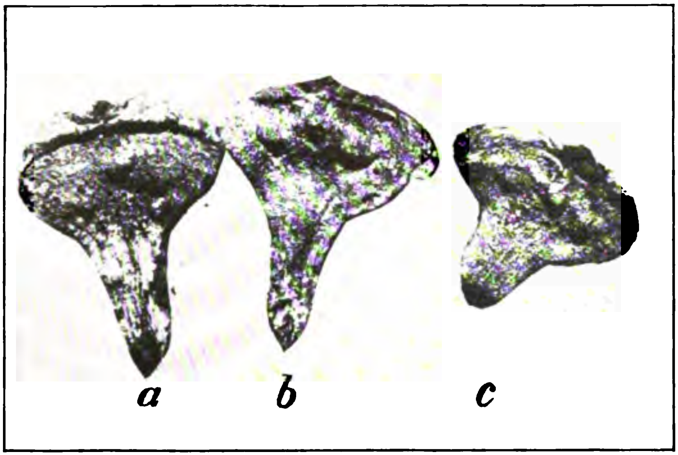
PLATE 2

FIGS. 1–5.— *Protodammara speciosa* n. gen. et sp., enlarged. Kreischerville, Staten Island, N. Y.

Figs. 1 a, b, c, 2.— Upper surface of cone scales, × 10, or more.
Fig. 3.— Transverse section of the base of a scale, × about 40.
Fig. 4.— About half of a transverse section of a scale, × 50.
Fig. 5.— Longitudinal section through the apex of a scale, × 40.



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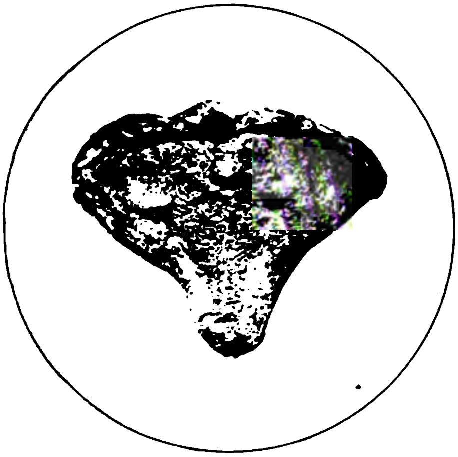

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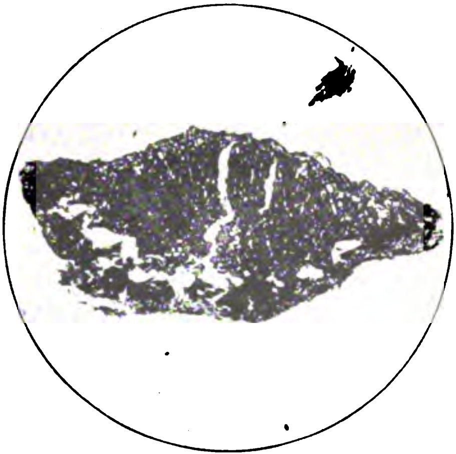

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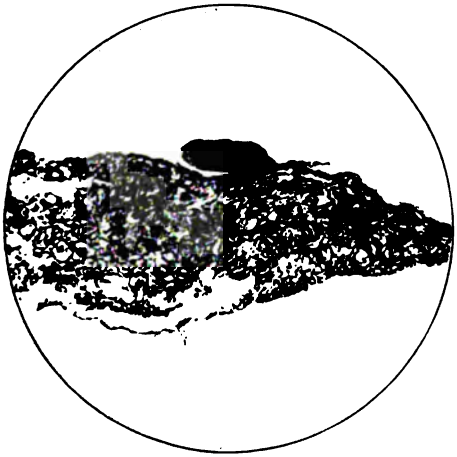

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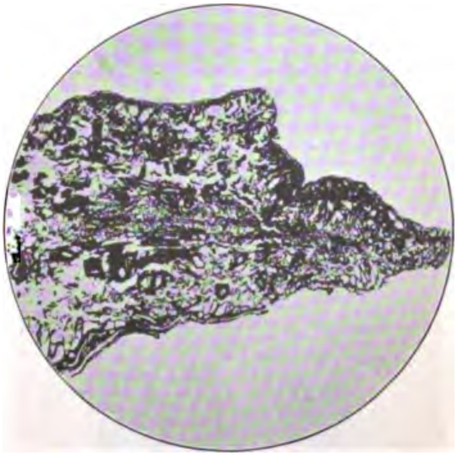

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PLATE 3

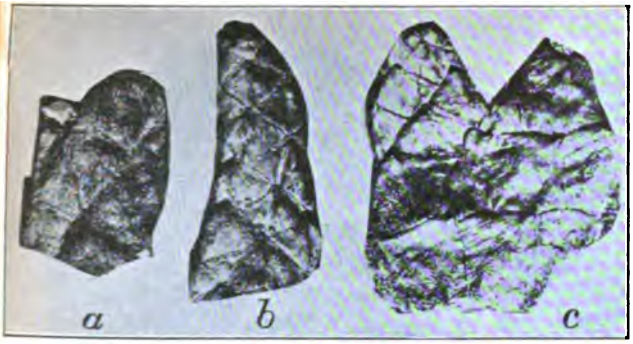
Figs. 1–5.— *Brachyphyllum macrocarpum* Newb., enlarged. Kreischerville, Staten Island, N. Y.

Figs. 1 a, b, c.— × about 6.

Figs. 2, 3.— × about 10.

Fig. 4.— Transverse section through a relatively old branch, × 8.

Fig. 5.— Transverse section through a young branch, × 15.



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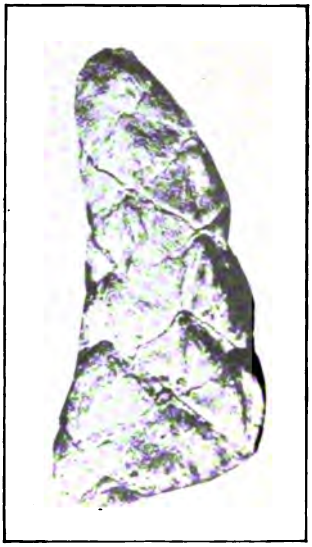

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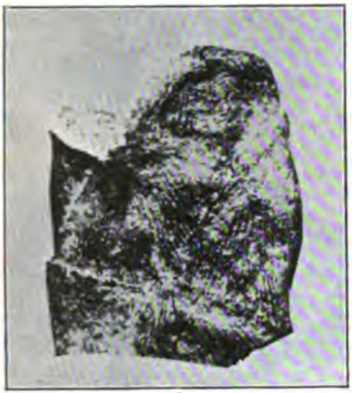

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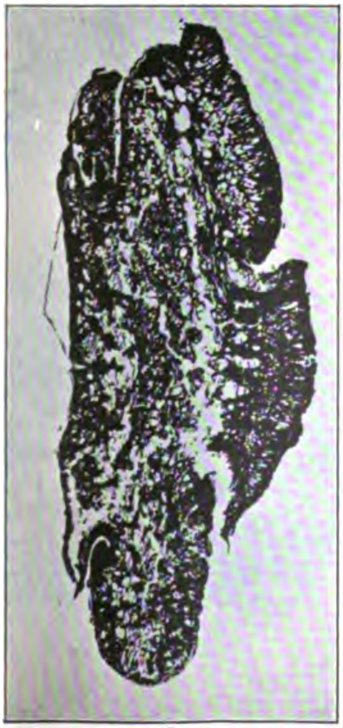

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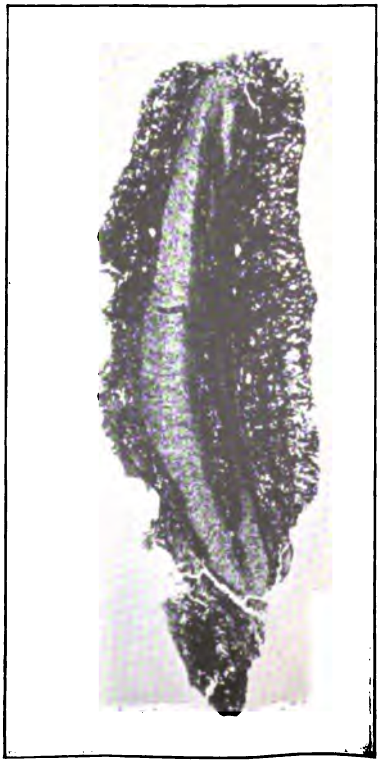

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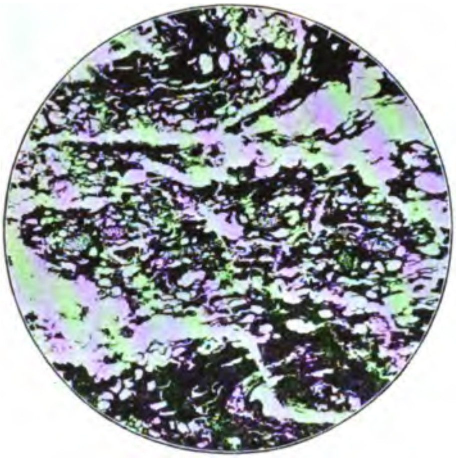

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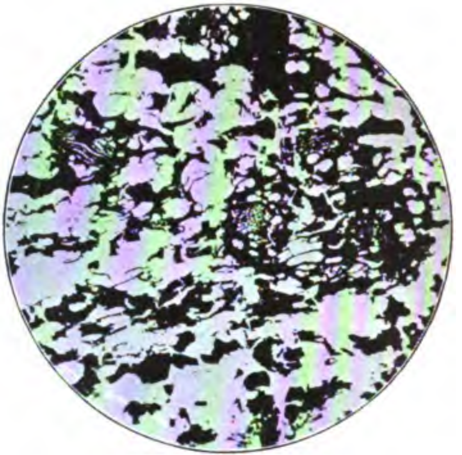

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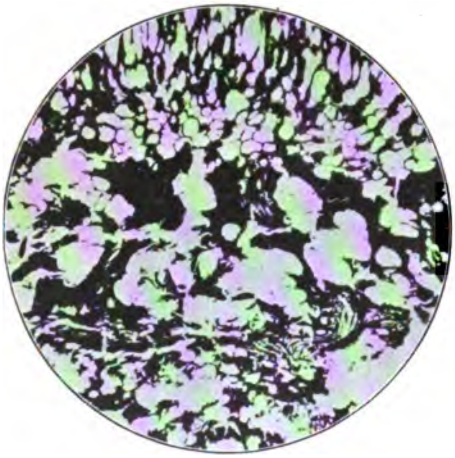

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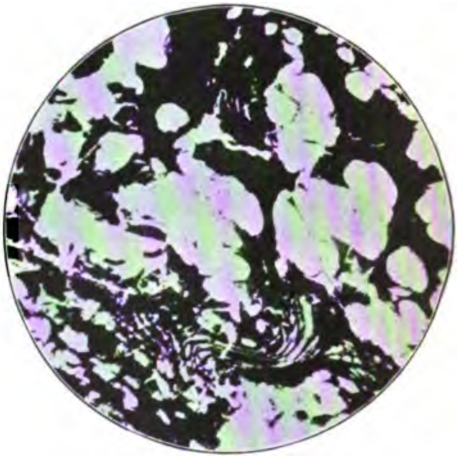

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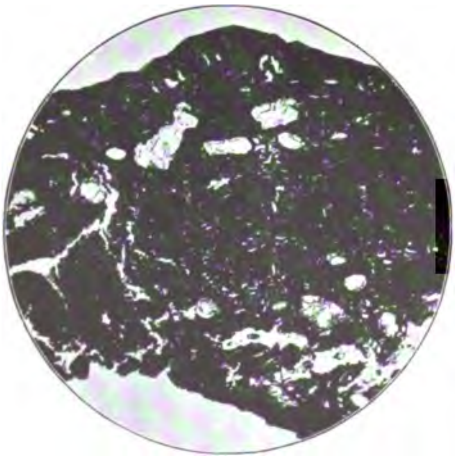

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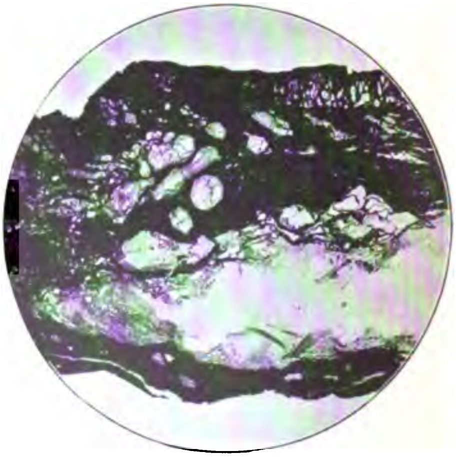

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PLATE 4

Figs. 1–6.— *Brachyphyllum macrocarpum* Newb. enlarged. Kreischerville, Staten Island, N. Y.

Fig. 1.— Transverse section through the young woody cylinder of the branch shown on Plate 3, Fig. 5.

Fig. 2.— Cross section of the basal portion of a leaf from the margin of the same, × 50.

Fig. 3.— Same, showing a branching leaf trace, × 50.

Fig. 4.— More highly magnified, × 70.

Fig. 5.— Transverse section of a branch, showing resin-canals, × 30.

Fig. 6.— Transverse section of a diseased branch, showing a particularly large resin-canal, × 30.

PLATE 5

FIGS. 1–4.— *Brachyphyllum macrocarpum* Newb., enlarged. Kreischerville, Staten Island, N. Y.

Fig. 1.— Longitudinal radial section showing the radial pits of the tracheids, × 200.

Fig. 2.— Medullary ray showing the characteristic Araucarian lateral pits of the ray cells, × 200.

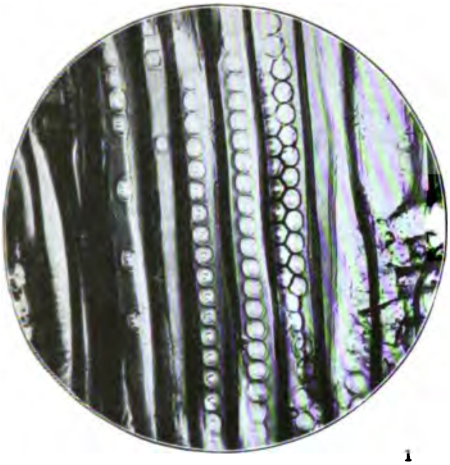
Fig. 3.— Transverse section of the xylem and phloëm in a yearling branch, × 200.

Fig. 4.— Transverse section of a young branch showing the xylem and phloëm, × 200.

FIGS. 5, 6.— *Araucarioxylon* sp., enlarged. Kreischerville, Staten Island, N. Y.

Fig. 5.— Transverse section of injured wood, × 50.

Fig. 6.— One of the traumatic resin canals of the same, × 150.



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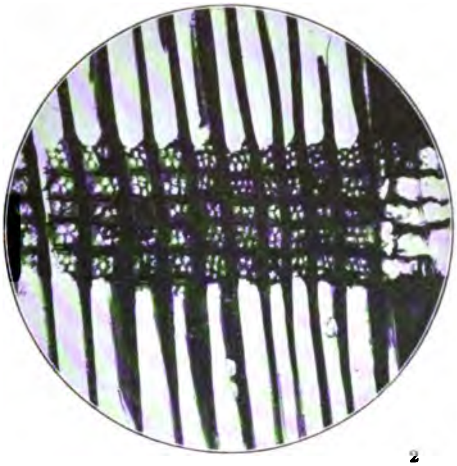

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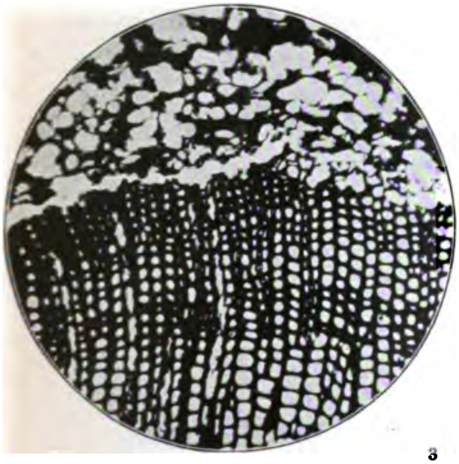

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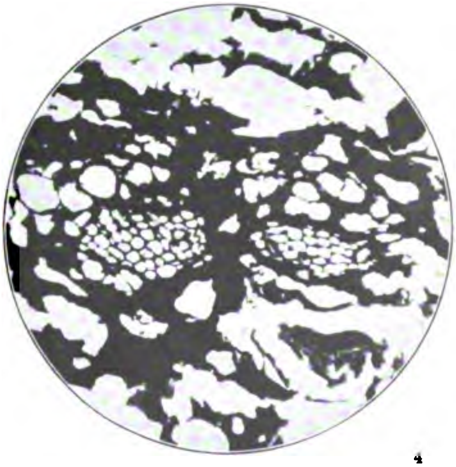

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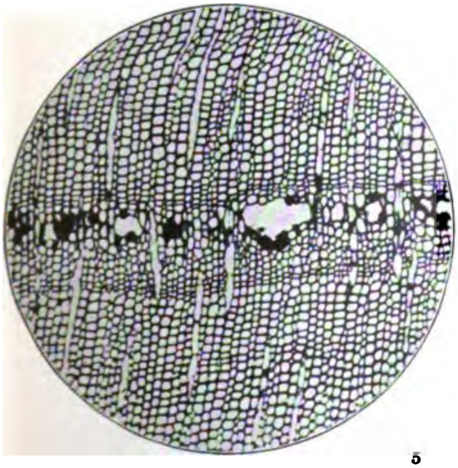

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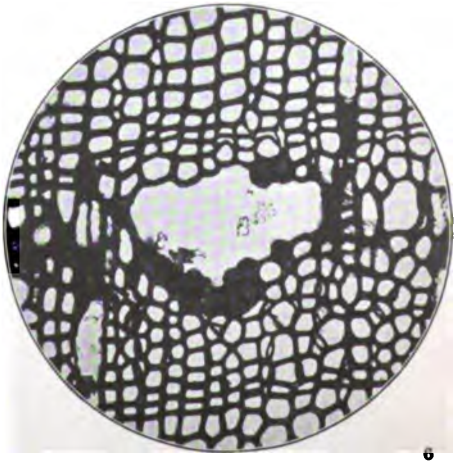

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CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 80.

HEREDITY

AND

THE ORIGIN OF SPECIES

LECTURE GIVEN BEFORE THE BARNARD BOTANICAL CLUB, COLUMBIA UNIVERSITY

DECEMBER 18, 1905

BY

DANIEL TREMBLY MACDOUGAL
DIRECTOR DEPARTMENT OF BOTANICAL RESEARCH,
CARNEGIE INSTITUTION OF WASHINGTON

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met since its beginning. On the contrary the succession of its forms is a most devious one, and by no means easily traced. Phylogenetic systems are made up chiefly of allowable suppositions, and it is altogether probable that we do not know more than a fraction of the course of the zigzag, halting, and at times, receding steps followed by living matter in its development into existing types.

Thus the mosses are seen to have reached the ultimate development allowable by their morphological character, and hence are incapable of any movement which will produce higher or better organized types. Accordingly we may assume that their existence as a constituent of the flora seems to be doomed to a diminishing importance, if not final extinction. The fern-like plants are also examples of a great phylum of the vegetable kingdom which, in the Carboniferous period, being most suitable for the conditions present, constituted the prevailing type of vegetation, making up perhaps as much as three-fourths of the plant-covering of the land. Their organization is one which promises nothing of advantage vegetatively and reproductively, and we are now at a time when we see them slowly but inexorably, being supplanted by seed-producing forms.

With the advance and retreat of the ice-sheets, the upheaval and submersion of land areas, and other great alterations in the earth's surface the hosts of plants have marched and countermarched across the face of the world, now losing thousands of species, the remains of which we exhume from ancient battlefields; now entering upon new possessions and increasing the numbers of species and forms by originating new types, which survived or perished according to their fitness or unfitness. In the interpretation of the traces of these major movements of living forms great care must be exercised in distinguishing the essentially different factors affecting the distribution of plants and animals. It is as if two games of checkers were being played on an enlarged board at the same time, the moves of each player being governed by those of his opponent and interfered with by those of his neighbor, and the two players on one side of the board by no means advance, guard and retreat in parallel fashion, while their losses and gains may be wholly disproportionate. With regard to the application of this warning note it is to be said that the "naturalists," as some zoologists term themselves, having made the greatest number of essays to offer a universal interpretation of the problems of distribution are to be credited with the greatest number of defenceless assumptions. In all developmental and evolutionary researches too much emphasis can not be laid upon the basal fact that the physiological and morphological nature of the two great classes of living things are so widely divergent, that the derivation of universal biological principles from their apparently concurrent behavior, must be made with the greatest caution.

Let us pass at once to the basic problems of life, those of the origin of characters and their inheritance, by which new species arise. Very naturally the first statement advanced was a purely theological one, that species were created directly, and that we need not expect to find an explanation in natural causes.

Of the hypotheses that may be taken more seriously, one that has even lately been regarded with much favor, predicates that organisms undergo transformations, or alterations by adaptive changes in their organs and entailed functions, as a direct reaction to environmental factors, and the altered features becoming fixed and inheritable, the organism receives a lasting imprint from its habitat. Migration to new areas, or changed climatic conditions might give opportunity for new stimuli and different reactions which might, or might not, affect those previously made. We need not, at this time go into the intricacies of the arguments that cluster about this main thesis, or weigh the evidence that is drawn from the presence of useless, vestigial, and useful characters in various organisms.

Popular belief in the influence of environment and the inheritance of acquired characters finds its commonest expression in "that plants have been changed by cultivation." Domesticated races are spoken of as "garden forms" by botanists and horticulturists, with the implication that they are specialized types resulting from the effects of tillage. Now so far as actual cultivation is concerned, this assumption is without foundation, since at the present time no evidence exists to show that the farm, garden or nursery has ever produced alterations which were strictly and continuously inheritable, or were present, except under environic conditions similar to those by which the alterations were produced, although vague statements and erroneous generalizations to the contrary are current. It is true of course that structural and physiological changes may be induced in a strain of plants in any generation, which may persist in a share to the second, or even in some degree to a third, but no longer. Some very important operations of the market gardener and the farmer are dependent upon this fact.

The possibility that permanent changes might be induced is by no means to be denied, and it is a fair subject for investigation. Actual evidence is to be obtained only by observations of breadth under guarded conditions. Until this is at hand all affirmative conclusions can be but inferential and suggestive.

Vicinism, the somatic multiplication of bud-sports and extreme variants from a fluctuating series, and the confusion of closely related elementary species form the basis for the greater number of mistaken assertions as to the effects of cultivation. It is obviously necessary to examine all facts bearing upon the lineage of supposedly new forms, with the greatest care before their aspect, or behavior may be taken as evidence upon phylogenetic problems.

The theory of natural selection of an intra-specific application, as one of which new forms might arise, is so well known that we need not particularize in defining its ramifications. Briefly, it is assumed that as the whole mass of individuals comprised in a species is in a constant state of variation the individuals which show features even the most slightly better adapted to the environment, survive while the less fit perish. Thus by infinitely small changes during each generation a species moves away from the ancestral type in one or more directions until in the course of thousands of years the differences become so great as to be appreciable, and of a specific character, to use an arbitrary phrase. Three unsurmountable objections to the acceptance of this method as universal present themselves. First, the fluctuations exhibited by the individuals comprised in a species do not in any known instance transgress definite measurable limits, and do not depart from an ascertainable norm or average. Secondly, the gradual transition of individuals from one type to another, that is intergrading forms, demanded by this theory, are not found among plants, and thirdly, although we have preserved specimens and records of several species which cover their history for many thousands of years, yet such gradual transformations are not observable. Lastly it is to be said that it is extremely doubtful if the earth is old enough to have permitted the development of the great number of organisms which inhabit it, by this method.

A secondary idea that has been formulated in connection with this subject is that of orthogenesis, by which the organism evolves rudimentary structures purely as a result of internal forces, and initially without reference to utility, or to environment. These rudimentary organs may, in the course of generations wax in size, undergo increasing differentiation of structure, perhaps finally becoming sub-functional or even fully functional, although nascent organs are not always supposed to attain this useful end. In support of this theory it has been pointed out that plants and animals show many structures, which so far as our understanding of them goes, are wholly without part in the life of the organism. The present development of plant morphology, however, is one which is carrying us farther and farther away from the conception of such pre-functional formation of organs, as the whole tendency of modern investigation is to place the morphogenic processes upon a physiological basis. On the other hand the argument that the variations of the organisms are "determinate," and are governed by the morphological possibilities is one which surely holds for any method of phylogenetic procedure. Thus it needs but the briefest common-sense consideration to show that any given type of leaf or flower, could not possibly vary toward all other types, but only in the direction of certain forms not too widely different.

A more explicit statement may prevent a misconception. It has been held by some writers that variations and mutations, theoretically follow those already made, as a projection of them, or a continuation, which carries the organs concerned, successively and ever nearer some ideal form or type. This is determinate variation in its strictest sense. On the other hand, it is argued that from any given stage in its development an organ may vary or mutate in any direction limited of course by its morphological possibilities, and such alteration may lead the structures concerned in any given course from that previously pursued. It need only be said that to the experimenter the latter view seems to be the more fully justifiable by the facts observed in mutations.

Of the many other phases of the existence, and distribution of organisms, that have been considered in a controversial way to prove this, or that, hypothesis it must be ceded that in this discussion of the effect of isolation upon the origin and preservation of forms, the evidence adduced, so far as plants are concerned does not especially favor any of the suppositions discussed previously. In like manner the bogie of the effects of close- and cross-breeding is used in the most reckless manner to support the most diverse generalizations. Until investigated with the exactness demanded by modern technique, and by the most approved methods with material of undoubted pedigree, we may well consider close- and cross-fertilization as operations the value of which is yet to be estimated. Nearly all of the available data have been obtained with domesticated races, artificially selected from what, in the natural conditions, may be the most extreme phase of a character, and far from the norm of the species in many particulars. The retrogression toward this norm may be a deterioration of the economic value of the strain, yet from the point of view of the species itself it may be a direct movement toward the average condition, in which we may not secure so much speed, beef, wool, milk, grain, or fibre, as in strains bred and selected for these features.

It is with great relief that we turn from these historical and hypothetical considerations to the authenticated facts, the interpretation of which affords some positive generalizations as to phylogenetic procedure. In other words we take up the observations by which species *have* arisen, in place of the suppositions as to how they *may have* arisen.

First, it has been known for over half a century that fixed forms, constant in inheritance and self-maintenant, therefore constituting species have resulted from hybridization. The fertilization of the egg-cell of one species by the pollen of another, often results in an interlocked and stable combination of the characters of the parental forms in such manner as to give rise to a new type unlike either of the parents, variously intermediate and constant to the new type in succeeding generations. More than a thousand such fixed hybrids, or hybrid species are known, some of which have been formed anew experimentally and are thus beyond doubt. It is to be seen therefore that hybridization has played, and is playing, no small part in the composition of the flora of the earth, and that it must be considered as an active, and not unimportant factor in the evolution of plants.

It must be admitted at once that such fixed hybrids are exceptions to accepted principles of dominance, and of the purity of the germ-cells, as the fixed hybrids depart entirely from the Mendelian procedure. As a further complication we have in some instances a hybrid progeny comprising several fixed types, each constant to itself. The only possible explanation of such phenomena in the simpler case calls for a fusion of the germ-cells and a double longitudinal division of chromosomes.

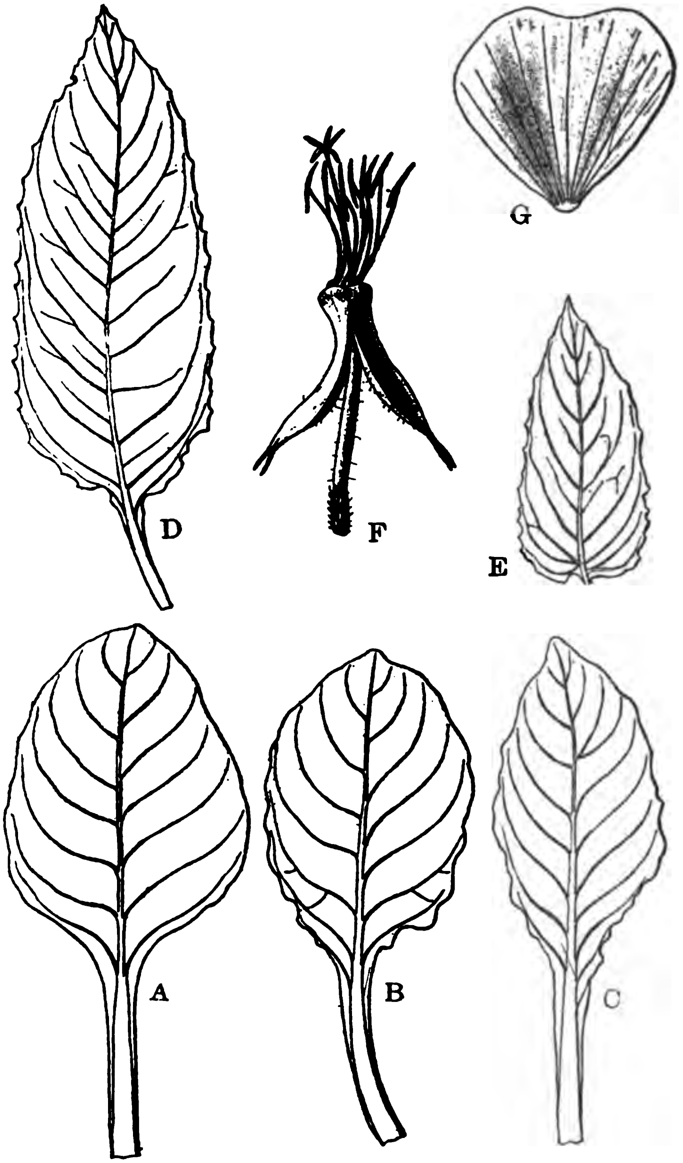
Such splittings are qualitatively unsymmetrical, since the fixed hybrids are variously intermediate between the parents, sometimes being goneoclinic to the one furnishing the pollen, and in other cases to the one bearing the egg-cell. When it comes to the composition of a hybrid progeny which comprises several fixed types in the first generation, breeding true in succeeding generations, we can only look to the researches of Wilson and others upon the quantitative and qualitative inequality of the chromosomes to furnish us the proper clue. It is only fair to say that no investigation of such cases has yet been made. Now as to a third category in which the hybrid is polytypic in the first generation, and some or all of the types may split in the second generation into forms, which may or not be identical with the grandparents, we evidently have a complex case in which the partial fusion of unequal chromosomes, with divisions of the chromosomes may operate in a manner to secure anything but purity of the germ-cells. The results of such complicated integrations and splittings are incidental to the scope of this lecture however, as we are concerned at present only in those cases in which fixed forms result from hybridization, chiefly in the first generation. So far have we advanced, however, in the study of the behavior of hybrids, that with the information obtained from them, and with the recent discoveries as to the differences of chromosomes, we may well believe that we are now at the dawn of a new day in the study of heredity and all of its associated problems, in which the greater results are to come from the proper and closer correlation of the researches of workers in all branches of natural science.

The second method by which new characters and new species have been seen to arise in the succession of generations in plants is that of discontinuous variation, or mutation. In following out the germination of hundreds of seeds in pedigreed strains of plants, a few individuals may be found in each generation, which are notably different from the type in anatomical and physiological features. These divergencies are variously heritable, constituting breaks in descent, by which, in some cases, new species originate. Such seed-sports or seed-mutants have been seen hundreds, perhaps thousands of times during the last two centuries, but it is only within the last twenty years, that their phylogenetic importance began to be appreciated. It will be of interest to this assembly to know that American botanists and horticulturists have made early observations of direct interest in this connection. Thus Dr. Arthur Hollick, while a student at Columbia University in 1879, said in writing of white varieties of colored plants: "First then, we have to consider those sports of nature where there has been a sudden change, without any intermediate steps, from a plant with colored flowers to a pure white variety: such may be termed "negative" varieties, since their peculiarity is due rather to an absence of color, than to the presence of white. Not only does the flower show the characteristic absence of color, but the leaves, stem, and, in fact, the entire plant, are invariably of a lighter green; and if any red be normal to the stem (which is often the case), this will also be of a lighter shade. It has often been urged that these albinos are mere 'sports' of nature with nothing constant about them,. . . ., and that there is nothing inherent in the constitution of the plant. Fortunately I have been able to test this,. . and found them, . . not only constant in their peculiarities, but also that these are bred in the plant and capable of inheritance." Three years later, about the time that De Vries began casting about to find material suitable for the demonstration of his theory of unit-characters and their saltatory action, Mr. Thomas Meehan, a horticulturist of Philadelphia, wrote as follows, in a discussion of some anomalous form of the oak: "The conclusion that I have been forced to is that the odd forms we often find in nature are not necessarily hybrids, but are as likely, if not more likely to be the outgrowth of some internal law of form with which we are as yet unacquainted. That they do not often perpetuate themselves is (*not*, plainly implied) remarkable when we remember that of thousands of seeds produced on any one tree, but a very small percentage ever gets a chance to form, and of those which do sprout, again but a small percentage survives to become bearing trees. As the number of trees reproducing the general features of the original may be as a hundred to one of the more strikingly aberrant forms, we may see that though individual instances may be common, we are never likely to meet many trees of one stamp. Once in a while an individual tree may find itself in a situation favorable to the preservation of a number of seedlings, which might endure until again reproductive; in such cases a marked variety may originate and make its way over the earth.

"I have often thought it probable that in time a few individuals of these suddenly introduced forms might again leap into new features, and then if they should be able to sustain themselves, we should have new species quite independently of any principle of natural selection; that principle, as I understand it, being governed chiefly by 'environment.'"

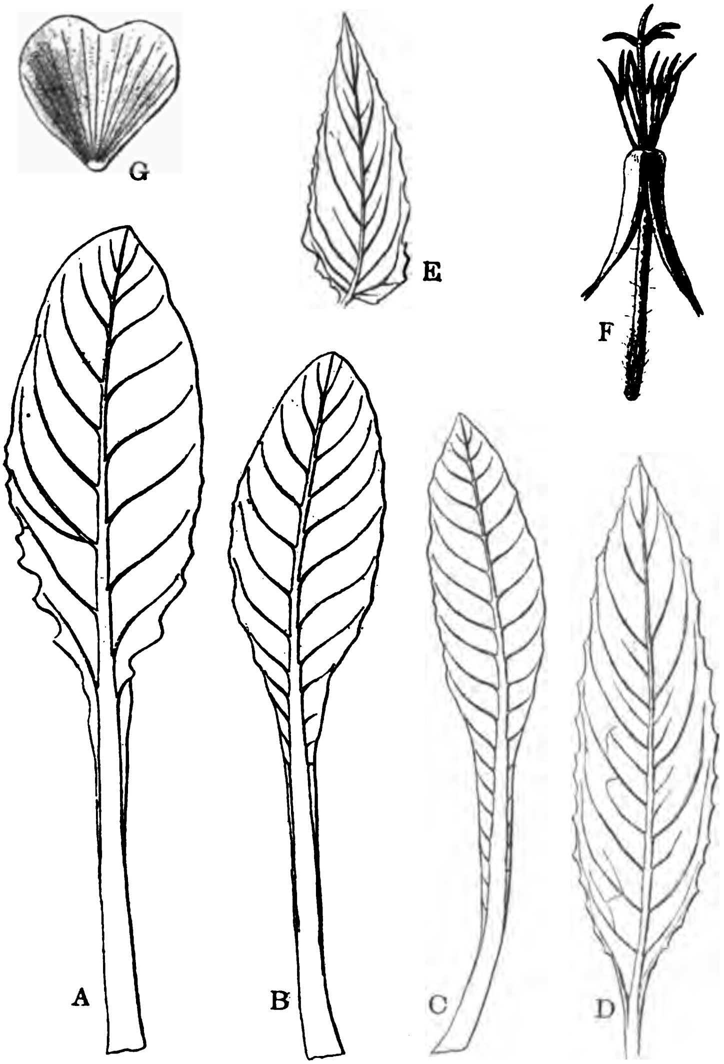
These utterances may be taken as prophetic in part, and in part as a natural expression of the inadequacy of explanations of the origin of species current at the time. Shortly afterward, Professor De Vries, impressed with the necessity for obtaining positive evidence upon the subject, began an examination of the plants in the vicinity of Amsterdam, Holland. Over a hundred species were brought into cultivation, and tested by guarded pedigree-cultures, and every precaution was taken to exclude interference of agencies which might introduce errors. It is impossible to describe the enormous amount of work entailed in such investigations, but the truly splendid results well justify the tedious care by which lines of descent were carried through successive generations for two decades without allowing a trace of doubt as to the purity of the lineage involved.

During the last four years a partial duplication and an extension of these experiments has been carried on in New York. It seems unnecessary at this late date to go into the detail of the mutations of Lamarck's evening-primrose, especially since the phenomena exhibited by them are also to be seen in many other species. By way of illustration it need only be said that this plant, as originally observed by De Vries, was found to give from two



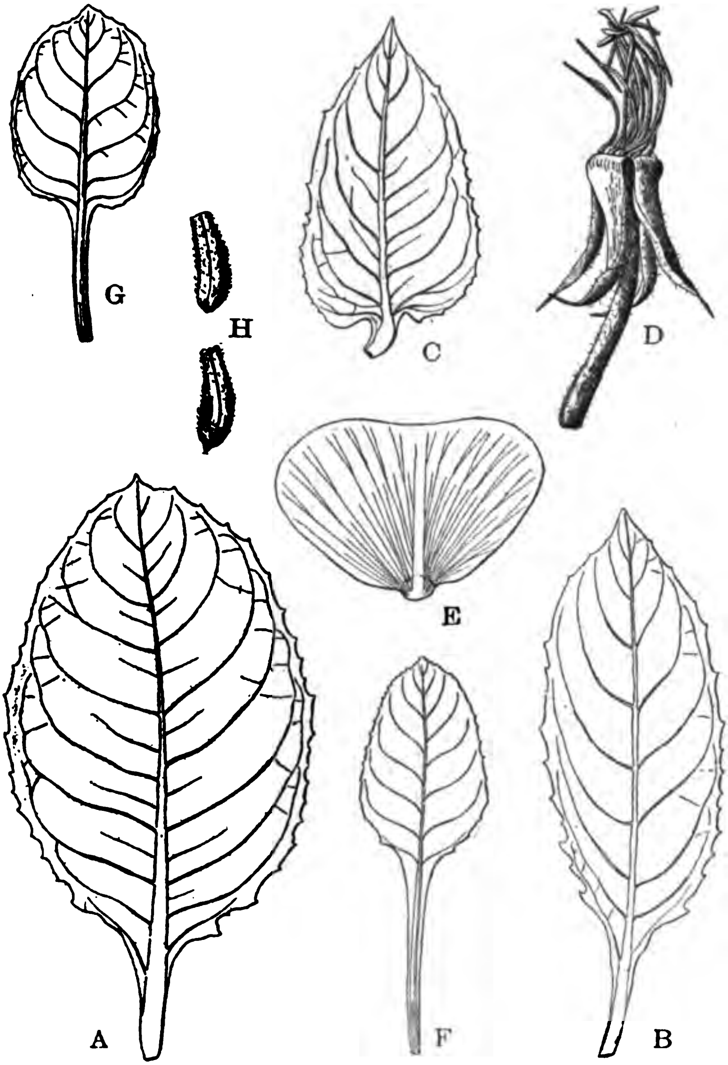
Oenothera Lamarckiana, the parental form which is giving off many mutants. A, B, and C, leaves from rosette. D, leaf from middle of flowering stem. E, bract. F, flower with petals removed. G, petal.

to five plantlets in every hundred which were widely divergent from the type, and could, upon maturity, be arranged in several groups, and in fact constituted several possible species. One, *scintillans,* was eversporting, and



Oenothera rubrinervis, One of the Mutants of *O. Lamarckiana.* A, B, and C, leaves from rosette. D, leaf from middle of flowering stem. F, flower with petals removed. G, petal.

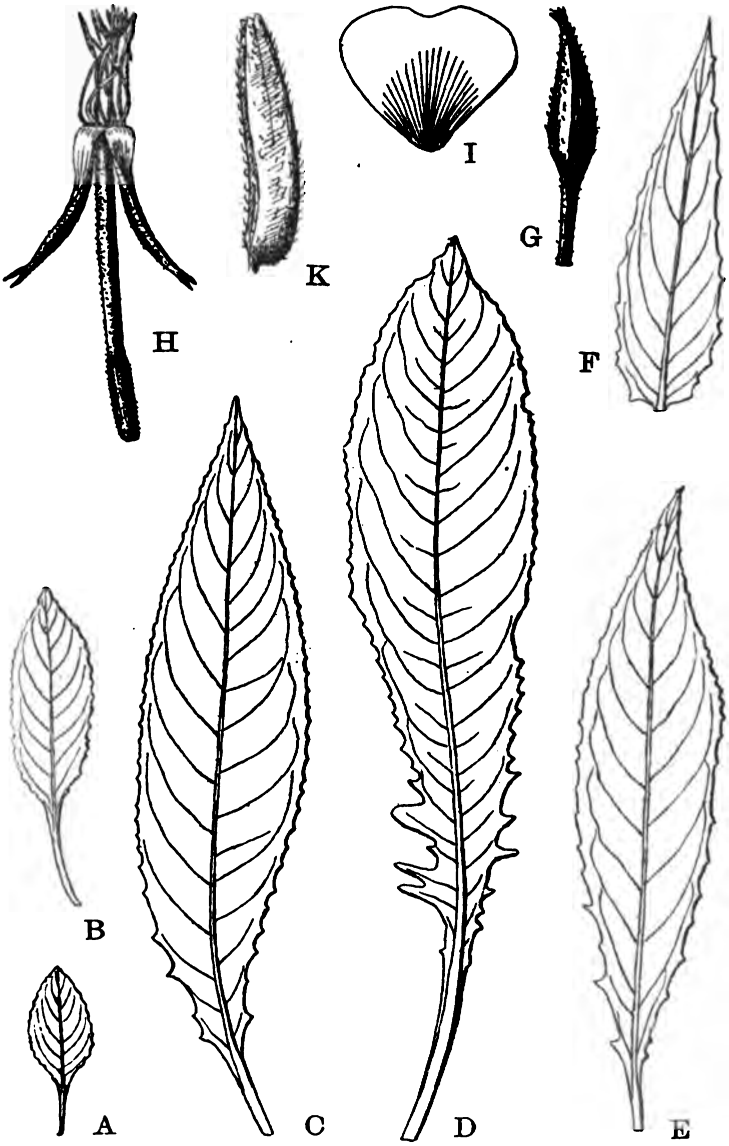
continuously and consistently gave rise to a variety of forms in its progeny, which included the parent and its mutants. Another, *lata,* was imperfect and did not mature pollen, and hence was incapable of independent existence.



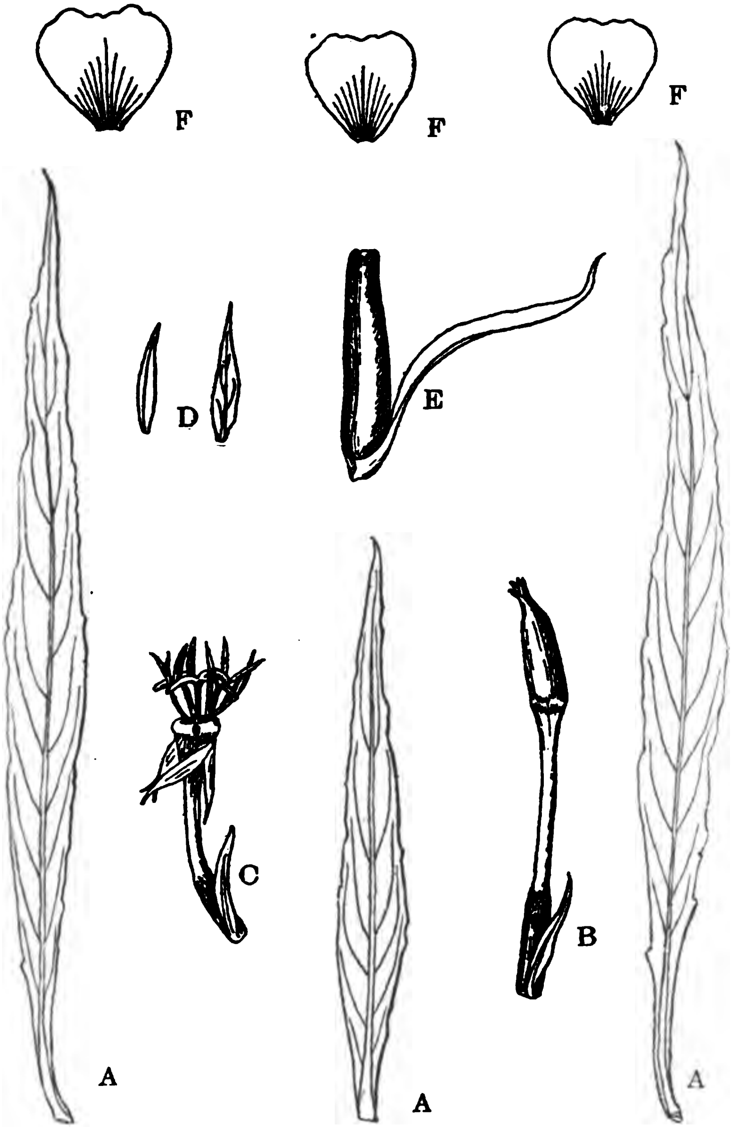
Oenothera gigas, One of the Mutants of *O. Lamarckiana.* A and B, leaves from middle of main stem. C, bract. D, flower with petals removed. E, petal. F and G, leaves from the rosette. H, capsules.

Others were perfect and vigorous both vegetatively and reproductively, and have been found capable of sustaining competition with the parental type. Of these *rubrinervis* grows more rapidly, germinates its seeds more quickly, and makes more numerous branches, and bids fair to be able to win out in a struggle with the parent in all of the phases of the struggle. *Gigas* is a more vigorous form than the parent, and both it and *rubrinervis* show a tendency to predominate when crossed with the parent. *Brevistylis* was found in the original location from which the mutating strain was taken, and as it has not appeared in any of the pedigreed cultures of the parent type in twenty years and still maintains itself in the original locality, it may be designated as a mutant which not only has arrived, but has survived under perfectly natural conditions. Recent cultures in the New York Botanical Garden from seeds of Lamarck's evening-primrose, sent from various parts of the world where the species is under cultivation, demonstrate that it is not alone the plants observed by De Vries at Hilversum are mutating, but the same derivatives are being given off in widely separated localities.

Purely-pedigreed strains of other species of evening-primroses have also been tested with the result that I am able to announce that three species are mutating, in lines of descent which came from wild plants one and two years ago. The common evening-primrose, *Oenothera biennis*, gives rise to one atypical individual in every two hundred seedlings, which during its entire development is continuously different from the parent in many features. It reproduces itself, after the manner of *scintillans,* appearing to be eversporting and giving many of the parental individuals in the purely fertilized seeds. Within the last two months a single rosette representing a new and unknown type has appeared in the seed-pans appearing to be a mutant which is found not more than once in twelve or fifteen



The Common Evening-primrose (*Oenothera biennis*), which is giving off one or more mutants. A, B, C, and D, leaves of the rosette. E, leaf from middle of flowering stem. F, bract. G, bud. H, flower with petals removed. I, petal. K, capsule.



A Mutant of the Common Evening-primrose. A, A, leaves of the rosette, and from the stem. B, flower-bud. C, flower with petals removed. D, bracts. E, capsule with bract in profile. F, petals.

thousand plants. The evening-primrose of the Adirondacks and northern New England, *Oenothera cruciata,* has been found to give atypic individuals conforming to a single type, which is also represented by specimens that have been collected in a wild state, so that here also, we have the survival of a species which is still arriving in a large proportion of the progeny. The great-flowered evening-primrose, *Oenothera grandiflora* of the southern states has been grown during two generations and it also is found to give derivatives, one or more of which appear to be already represented in the flora of the region.

One of the most interesting correlations to be made from a study of the results of these observations is to be found in the parallel mutations exhibited by the several species, in apparent contradiction of the principle of radiate variation and mutation (*allseitige Mutationen*). Among these are to be mentioned the origination of a form with cruciate flowers of the same general form as the *Oenothera cruciata* of the Adirondacks, from the species known as *O. biennis* in Holland, which is not identical with any species known to grow wild in America. The same species has also been seen to give off a mutant having the character corresponding to the mutant *nanella,* coming from *Lamarckiana,* according to De Vries. Then an evening-primrose of unknown identity has been found on Long Island by Dr. Shull, far removed from the locality inhabited by any other cruciate plant, and strongly suggestive of a mutation from *biennis* or some other form native to that locality. Such facts merely show that the forms borne by nearly related species lie well within the limits of the morphological possibilities in saltations and that they may be expected to be duplicated in other observations.

Scattered through the literature of botany and horticulture of the last century are scores of records of the sudden appearance of sports and forms of the aspect of species which fully support all of the conclusions drawn from the observations on the evening-primroses. An examination of the facts easily brought together allows us to see that certain general principles in the organization of the plant, and in its behavior in these breaks or saltations in heredity may be made out.

The first and most important of these is one which was advanced by De Vries speculatively, before he began his experiments in heredity, namely that the plant is essentially a complex group of indivisible unit-characters. These unit-characters may not always be expressed, or recognizable in external anatomical characters, since they may be in a latent condition, or totally inactive, or external taxonomic characters may really consist of several elementary qualities, but these are not shown in any intermediate stage although they may be modified within the limits of fluctuating variability.

Any plant, supposedly, includes thousands of unit-characters, and as they are essentially qualities, or capacities, they do not usually coincide with the characters ordinarily used in taxonomic descriptions. As an illustration, the phases of geotropic sensibility of an organ may be considered as a unit-character. Thus a branch is either apogeotropic, directing its tip directly upward, or it may be diageotropic placing its axis in a horizontal plane, at right angles to the action of gravitation, or it may undergo a mutation and "weep" or direct its tips directly downward. In any case, however, it possesses one of these three forms of reaction. It does not follow, however, that all branches are actually in one of these three positions, for other forces to which it reacts may operate to place the axes in various planes, and the position of the branch may express just such concurrence of elementary characters as alluded to above, or indeed the geotropic unit-character may be latent, and the organ may respond to other forces exclusively. Similar analyses must be used in the delineation of all unit-characters, and it is obvious, without further discussion, that we will never be able to uncover, either theoretically or actually, more than a few of these indivisible units. The forms and activities by which we recognize plants must by no means be taken to be simple in their constitution unless proved to be so, and the modification of a character in hybridization and otherwise must be taken as proof that it is not an elementary feature.

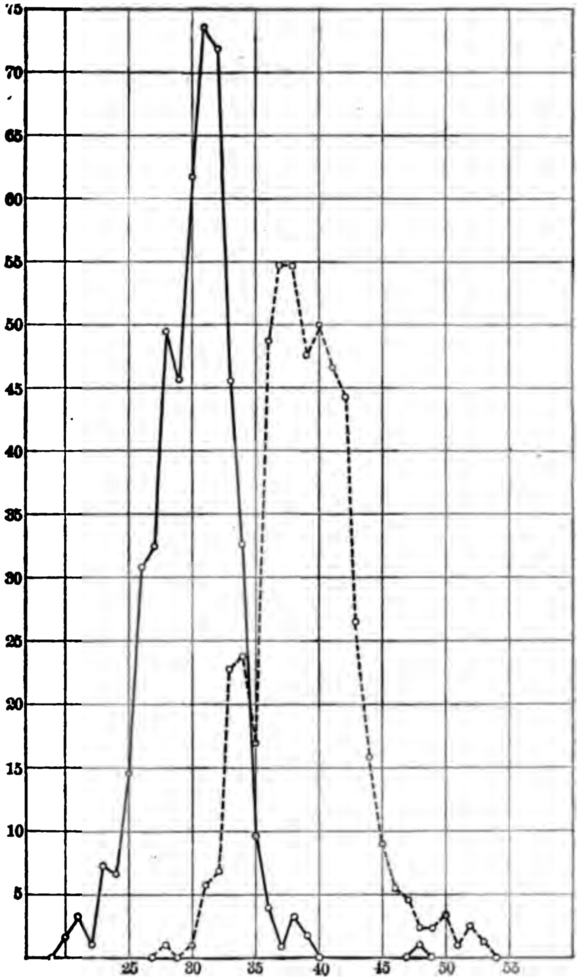
In tracing the development of species it is found practicable to designate them as retrogressive when a distinct unit-capacity, or unit-character is lost or, rather, becomes latent. Thus the loss of color must be of this kind, and also the loss of geotropic reaction, while the power of forming laciniate leaves when shown by mutants from a simple-leaved type would be estimated as a progressive mutation, as the group of characters concerned belong to a more highly organized type of organ. If a white-flowered species should give rise to a form with colored flowers it might well be taken as a degressive movement, or as a retracing of a step once lost, since all flowers were in all probability originally colored. Here again the actual test is hybridization, it being accepted that the retrogressive forms of organs are recessive or latent when crossed with the parental or nearly related types.

As to latency we can only say that strains of plants do carry capacities of one kind and another for many generations without these particular forms of unit-characters showing any activity. Thus a mutant which springs from a parental type, and shows a laciniate leaf instead of the ancestral leaf, must carry the latter form in a latent condition. The latent character may be awakened from time to time, or may be entirely and permanently inactive. The most easily analyzable examples of latency are seen in hybrids. Thus when the blue-flowered *Veronica longifolia* was crossed with a white-flowered variety derived from it, the progeny was entirely and continuously blue-flowered except for occasional bud-sports. The white-flowered condition was here very evidently in a latent condition. In other instances white-flowered forms have appeared as a recessive, forming one-fourth of the progeny. If qualities have a cytological basis, and we may certainly assume that they do, then it is not easy to speculate intelligently on the probable condition of latent characters.

A very striking feature of mutants consists in the fact that the gross anatomical characters in which they diverge from the parent shows a much wider range of variability around its new norm, than does the homologous character in the parental type. Many observations bearing this interpretation have been on record for some time. Chas. Darwin in his *Origin of Species* noted that varieties varied more widely than the closely related species from which they were supposed to be derived, and many other observers have touched in one way or another upon the subject. Dr. Shull's recent researches upon this subject led him into the making of exact measurements, by which he also finds that the wide fluctuations of the mutant characters are accompanied by a lesser degree of correlation than prevails in the parental forms. Thus, for instance, the leaves of *rubrinervis* not only vary relatively more in width than those of the parental *Lamarckiana*, but the proportion between the width and length is not so constant as in the latter. Other organs of these and other species were subjected to exact measurements with similar results, while a large number of recent observations are known which justify the conclusions just stated. Of these the great variation of the length of the pistil in *brevistylis* in comparison, and the wide fluctuations in laciniate leaves are good examples. Many of the latter are known to be direct derivatives of simple leaved ancestors, and are therefore capable of easy observation. With these facts in hand the possibility suggests itself that we might be able to distinguish between a structure recently arisen and one which was borne by a related species for thousands of years, but the exactness of such estimates is a matter of conjecture.

It seems to be taken for granted by a great number of workers interested in this subject, that species showing wide variations of the organs are the ones most likely to offer a high frequency of mutations, and my correspondents in various parts of the country are constantly calling attention to these forms under such a mistaken impression. As a matter of fact we may confidently expect that the species which show the greatest variation, or are eversporting, are the youngest.

Now having obtained the result just described we find ourselves face to face with one of the most interesting and difficult questions in heredity. If the newly arisen mutant forms are more widely variable than the older ones, how do they ultimately become narrowed? If the greater number of species originated by mutation, as we confidently believe they did, then they must have shown a much wider range of variability than they do at present; by the operation of what agency has variability been decreased, and correlations made more strict? At the present time I am compelled to say that I can not make an intelligent suggestion. Again if new characters vary widely at first, and lose this power, would it be possible to estimate the age of any given character of a species from the degree of variability? The author of the investigations just noted suggests that the best prospect for evidence of value upon this point might be obtained by a comparative statistical study of more recent types of structures in the foliar or reproductive organs, and of older forms that have come down from the previous epoch. It certainly offers a most alluring field for research, and will doubtless soon receive attention.



Range of Variation of the Ratio of Width to Length of Leaves in the Parental *Lamarckiana* and One of Its Mutants. The dotted line shows that the range in the parent is 28-53, with a coefficient of variability of 9.53 ± 0.22 per cent., while in the mutant represented by the solid line, the range is 20-48, with a coefficient of variability of 10.30 ± 0.22 per cent.

Let us return to the question of the diversity of mutations which may ensue in any species. Theoretically a plant might show discontinuous variation in almost any direction, but this departure of course does not exceed an amplitude determined by the morphological possibilities. With all of these features taken into consideration however, it is to be seen that it might be possible for any plant in a mutable condition to give rise to dozens, or perhaps scores of types simultaneously, while on the other hand it may originate but one aberrant form at a time. Lamarck's evening-primrose is producing a dozen, and the common species but one or possibly two, while the great-flowered species is throwing off three or four, as far as

			X_2	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9			
				50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140			
				55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145			
	X_1																								
	-12	17					1																	1	
	-11	18			1																			1	
	-10	19																						0	
	-9	20			1		1	3	1															6	
	-8	21		1					1			1												3	
	-7	22				1	2																	3	
	-6	23						2	2	7	2		1											14	
	-5	24						1	2	6	2	1	2			1								15	
	-4	25						3	2	6	6	3	5	2			1							28	
	-3	26							3	5	6	11	3		1	2	1	1	1					34	
	-2	27							2	15	11	7	9	6	3	3				1				57	
	-1	28							3	4	10	8	16	5	9	1	2							58	
	0	29							1	2	11	19	10	3	6	5	1							58	
	1	30								1	13	12	10	16	10	8	1	2		1		1		75	
	2	31				1					2	11	18	21	6	3	1	1	1	1				66	
	3	32									1	8	17	20	8	7	3	3	1					68	
	4	33										1	9	9	7	6	3	2						37	
	5	34											1	6	15	5	7	1	2					37	
	6	35										2	3	4	13	5	2	1						30	
	7	36											1		1	3								5	
	8	37										1	1		1	2	1	2						8	
	9	38														2		1	2					5	
	10	39														2	1	1						4	
	11	40																1						1	
				1	2	2	4	9	17	46	64	85	106	92	80	55	24	16	7	3	0	1		614	

Correllation Table of Length and Width of Leaf in *O. rubrinervis.* $p = 0.6604 \pm 0.0119$.

our observations go. It will be profitable to analyze the consequences of the origination of diverse types simultaneously. In the case of *Oenothera grandiflora* it ranges from Kentucky southward to the Gulf over climatic and edaphic conditions of wide diversity. If it be assumed that all of the mutants are being given off by the whole species then these must be thrown into the struggle for existence under conditions widely different. In some cases one mutant finds itself equipped to survive in the given

		X_2	−9	−8	−7	−6	−5	−4	−3	−2	−1	0	1	2	3	4	5	6	7	8	9	
			45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	
			50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	
X_1																						
−13	24		1					1														2
−12	25				1																	1
−11	26			1	1																	2
−10	27					1	1		1													3
−9	28					1	1		1		1											4
−8	29						1	2	3	2	1											9
−7	30						1	2	2	2	3											10
−6	31							1			2	2										5
−5	32								2	2	4		2									10
−4	33						1	1	6	3	4	4	3									22
−3	34							1	1	5	8	3	3	1								22
−2	35							1	2	4	9	6	1	4	3	1		1				32
−1	36						1	1	1	2	5	10	4	5	1		1					31
0	37							1		3	11	9	11	8	5	3	1					52
1	38							1		4	3	11	10	16	3	1						49
2	39										3	7	7	8	4	1	1					31
3	40										6	4	9	6	12	3	4					44
4	41											1	8	10	5	5	1	4	1			35
5	42											2	7	9	5	3	2	1			1	30
6	43									1			1	8	4	2	2				1	19
7	44													3		6		2		1		12
8	45													1	1	1	1	2				6
9	46															1						1
10	47																				1	1
11	48																2				1	3
12	49													1					1			2
13	50												1									1
			1	1	2	2	6	12	19	28	60	59	67	80	43	27	15	10	2	1	4	429

Correllation Table of Length and Width of Leaf in *O. Lamarckiana*. $p = 0.7916 \pm 0.0090$.

environment, and it does so in competition with the native flora, including the parental form. In a different part of the natural range of the parental form, a second mutant might have the advantage, and it alone of the entire brood would survive, while a third would be the best form for still another set of conditions. So well in accord with the facts do we find this assertion, that it is not hazardous to predict that when a final survey of the distribution of *Oenothera grandiflora* and its mutants is made, some such arrangement will be found. With this idea we must also concede that many of the mutants, so far as our experience goes, do not meet at all the conditions suitable for their existence, and these perish. In brief we have natural selection, not a selection *within* species, but a selection *among* species, by which certain ones are elected for survival and others doomed to destruction no matter how numerously, or how long they may be thrown off by the parental type.

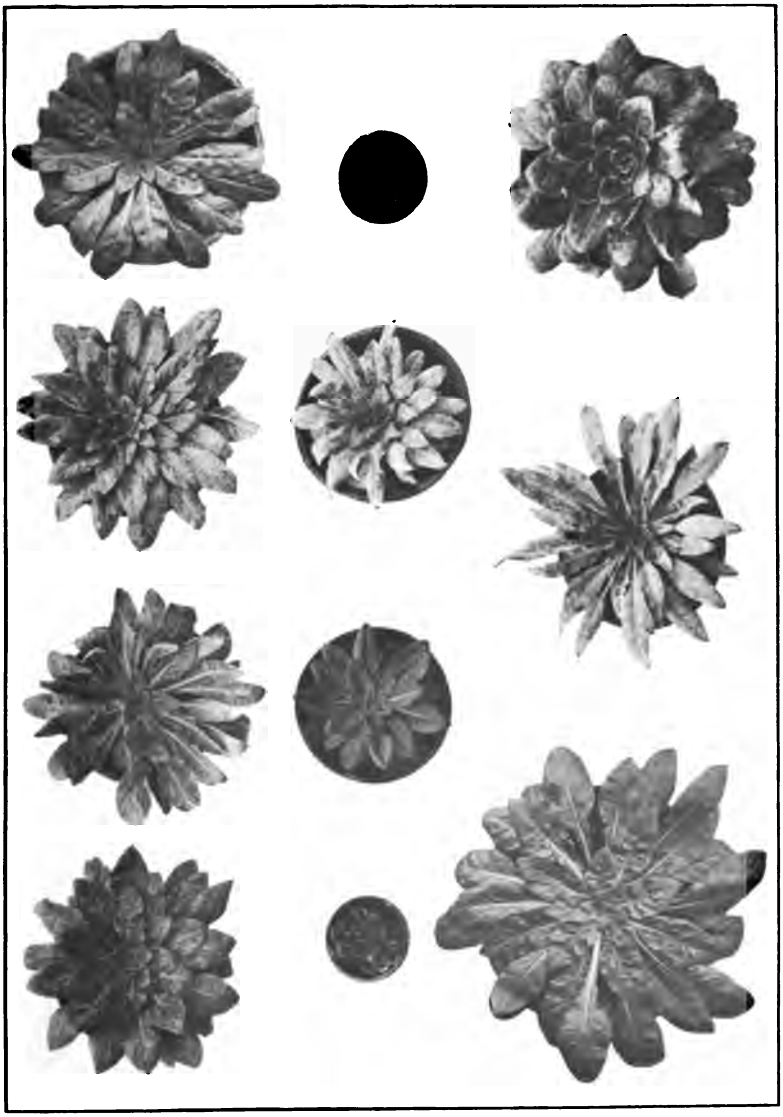
As to the periodicity of mutations our information is not very extensive. Does a species, as it produces generation after generation in the course of centuries, arrive at a point where it begins to give off atypic individuals, and is this process continued for a time and then discontinued? We can only say that we find some species mutating and others not, we have not seen either the opening or closing of the mutative period in any species. This consideration is complicated however with that of the frequency of the mutants. Thus in Lamarck's evening-primrose five in every hundred plants are mutants, one in every two hundred of *biennis,* and it is conceivable that the atypic form might not occur more than once in a thousand, or once in ten thousand, or once in a million. These large numbers of plants of any species are not all in existence at any one time, and it might take years, or even decades to bring one mutant within the range of the possible number, in which case a false conception of the mutative period might be gained. It is suggested therefore that the conception of *frequency of mutation* is the primary idea, although the action might become intensified in certain periods, of more or less definite limits.

Finally we may consider the causes inducing or affecting mutations. Mutants are found to be the most numerous under conditions most favorable to the growth and reproduction of the parental type, and this is also true of all anomalous structures. It is thus to be seen that mutations probably do not give rise to species most readily under the stress of unfavorable environment, or under any conditions which weaken the parental form, but when it is at a maximum of activity.

In the attempts to localize the changes in the cells, or in the chromosomes, which result in the formation of atypic individuals from seeds we are confident for theoretical reasons that these ensue previous to the reducing or qualitative divisions in the formation of the egg, or in the pollen mother-cells. Just what this change may be, we are unable to say, and shall probably know no more about it until the cytologist shall have given us some clue to the manner in which the separate qualities are represented in the chromosomes, in which the mutative changes must ensue. It is self-evident that in a mutation, some characters or qualities being borne along steadily from cell to cell in the divisions must be thrown into a latent condition, or perhaps totally lost, while simultaneously or separately, other qualities may be acquired by what actual operation we do not know. It seems fairly obvious, however, that these saltations arising from the non-uniform action of the chromosomes, must take place in response to some stimulus outside of the protoplast in which it actually occurs. This by no means supposes that the stimulation comes from climatic, or other environmental factors, but in all probability results from enzymatic or other action from neighboring masses of cells. If this is so then we may hope to be able to duplicate the process in our cultures and call out a proportion of mutants at our will. The results of experiments now in progress seem to lend great favor to this assumption.

This view of the case is also favored by the facts offered by bud-sports, which have been designated as "vegetative mutants, although as shown above, all mutations are essentially of a vegetative character. In the simplest forms of these sports, lateral buds arising generally near the base of a shoot develop branches which diverge definitely from the characters of the main shoot, and which usually coincide with some known form, although this is not always the case. Sometimes entirely new forms arise in this manner as in the case of seed-mutants. During the present season I have been so fortunate as to have three notable examples of bud-sports in the experimental cultures. One of these was a basal branch of *Oenothera ammophila* which sported into the characters of *O. biennis,* and suggesting a possible hybrid ancestry with the latter species as one of the parents. A second case was one in which a seed-mutant of *O. biennis* gave a bud-sport which bore the characters of the ancestral type or the true *O. biennis*. A third case was one in which a plant of one of the numerous types embraced in a complex hybrid progeny bore a branch which sported in a branch which resembled a sister type. Other anatomical relations are found. Thus a bud-sport may embrace not only a branch, but a portion of the main stem, from which it arises, or in other cases it may include a section or longitudinal strip along one side of a branch even dividing a flower or fruit, while in other cases it may be represented by single flowers or fruits scattered indiscriminately through an inflorescence.

It is to be noted that in most if not all of the sectorial variations by which a part of a bud bears the divergent



Lamarck's Evening-primrose and Ten of Its Mutants. The dense rosette in the lower left-hand corner is *O. Lamarckiana*, the parental form. *O. gigas* is in the upper right-hand corner, and under it is *O. scintillans*. The irregular rosette above *O. Lamarckiana* is *O. albida*, and to the right of *albida* is *lata*. *O. oblonga* is in the upper left-hand corner.

characters, the change is a reversionary one, and the qualities that appear are really latent in the entire plant, and only need some stimulus to awaken them, or some agency to weaken the dominancy of the prevalent characters.

In the case of the appearance of characters not hitherto borne by the main stock, the case is not so clear, especially as we feel fairly certain that the saltations do ensue, in seed-mutants at least, in single cells. Here the theoretical side of the case seemed least supported by facts and I set about supplying the deficiency with what success you may presently judge.

Bud-sports are usually found on the basal portions of main stems of shoots, or in that part of the main axis, which often shows juvenile structures, so that we may say that these breaks in heredity are very frequent in the closing part of the embryonic period, although sometimes occurring much later. On the other hand, the changes which result in the formation of seed-mutants must ensue in the very closing stages of the sporophyte, and here is encountered a feature not recognized in bud-mutations, that of a fairly constant frequency, which in itself would suggest internal causes. It was determined however to attempt to induce or influence mutation in one of these periods. It was deemed impracticable to attempt this in the early life of the sporophyte and attention was given entirely to the stage immediately preceding the reducing divisions.

Omitting the detail of technique I may say that strong osmotic reagents, and weak solutions of stimulating mineral salts were injected into ovaries in such manner that unfertilized ovules were subjected to the action of the fluids, which killed many of them, but which gave the much desired results in a few. In *Lamarckiana* and *biennis* the frequency and character of the known mutants was unaffected, but in the progeny of the latter species was found a single individual constituting a type hitherto unknown. This single aberrant individual might have been a mutant of low frequency, comparable to *gigas* derived from *Lamarckiana*, and its recurrence here might have been merely a matter of chance. However, in another species of evening-primrose, *Raimannia odorata*, a flower which belongs to a separate genus of the family, and is not known to be mutating, the treatment described resulted in a large number of aberrant individuals of a hitherto unknown type. Some of these, which show a shorter life-cycle than the parental form, and many anatomical divergencies, have been brought to bloom and to maturity, and the new form is obviously a potential species. In this experience, exemplified by specimens of the normal, parental forms, and aberrant mutants, I am able to offer you conclusive proof that agencies external to the cell may induce mutations, and consequently exert a profound influence on heredity. It would not be well to exaggerate the importance of this result, yet it is evident that the establishment of this fact marks a long step forward in the experimental study of inheritance and the origin of species.

A brief summary of the foregoing discussion may be made in the following generalizations:

1. Species may arise by hybridizations which result in fixed forms. A large number of forms known as species and recognized to be of such origin are known and a number of them have been duplicated in experimental cultures, some of which were made over a half century ago.

2. The mutation theory groups an enormous number of hitherto unexplainable facts, to which we are constantly adding in great volume, into a connected and meaningful whole, and best of all it brings the subject anew into a condition where it is amenable to experimental methods, in the laboratory, and experimental garden.

3. As a result of the theoretical conceptions offered us,

we have been able to make repeated observations of the general principles which govern breaks, or saltations in heredity, and to observe in what manner such mutations are connected with the origin of species.

4. Having ascertained at what time in the life-period of the individual mutations occur, I have been so fortunate as to secure results, demonstrating that mutations may be induced in a species not hitherto active in this respect, and that it is possible to call out new species by the intervention of external agents during the critical period.

5. Not less important than the foregoing is the unavoidable implication that breaks, saltations, or discontinuous action may be caused in inheritance by forces external to the protoplasts, and cells which are the true bearers of the hereditary characters.

Lastly it is of the greatest interest to note that in the effort to correlate the larger generalizations in the various departments of science in the concept of mutation we have hit upon a principle strongly favored by a modern system of mathematics, well exemplified by the spontaneous breaking-up and rearrangement of the complex atoms in radium, uranium and allied metals, and which has been recognized by Prof. George Darwin, the physicist, in the following words: "These considerations lead me to express a doubt whether biologists have been correct in looking for continuous transformation of species. Judging by analogy we should rather expect to find slight continuous changes occurring during a long period of time, followed by a somewhat sudden transformation into a new species, or by rapid extinction."

In the long-continued narrowing of the range of fluctuation in the various organs, coming to saltations, or direct origination of new forms, as the plant passes from generation to generation, we have as perfect a fulfilment of this motion as might be expected when an attempt is made to interpret the action of the living by the properties of the non-living.

DANIEL TREMBLY MACDOUGAL.

NEW YORK BOTANICAL GARDEN.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
GARDEN—No. 81

STUDIES IN ETIOLATION

BY AUGUSTINE DAWSON SELBY

NEW YORK
1906

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 33: 67-76, *pl.* 4, 5. 1906]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 33: 67-76, *pl. 4, 5.* 1906.]

Studies in etiolation

AUGUSTINE DAWSON SELBY

(WITH PLATES 4 AND 5)

During the winter of 1902–1903 the writer carried on certain studies of the effects of etiolation upon several species of plants in the laboratories of the New York Botanical Garden. Most of the species studied were latex-bearing sorts. Owing to the press of regular duties, and to ill health, the publication of the results has been long delayed — far too long, indeed. It seems, however, worth while to present them briefly at this time. An announcement of the results obtained with *Persea* was made before the Botanical Society of America at its Washington meeting, January 1, 1903.

Seedlings of the Alligator pear (*Persea gratissima*) were grown in a dark room and propagating houses of the Garden, toward the end of 1902. At the end of ten weeks the normal and etiolated plantlets had developed stems approximately equal in length (about 45 centimeters) which consisted of 17 and 19 internodes respectively (plate 4, figure 7). The variation in the length of the internodes of the normal plantlets was slightly greater than with the etiolated. No acceleration was shown in rate of growth by the etiolated plants, nor was the total amount of growth greater than in the normal. The stem-diameters were nearly the same in both cases. All the leaves of the etiolated stems were bract-like and rudimentary (plate 4, figures 3 and 4); these did not advance beyond a certain stage of 10 mm. in length, with blades 5 x 2 mm., when they withered and dropped off. These rudiments seem generally comparable with the rudimentary organs borne on the basal portions of the normal stems. At the end of the period of growth studied, four weeks later, the thick cotyledons of the normal specimens were very much shrunken, discolored and decaying, while those of the etiolated plants were bright, plump, and yet retained reserve material. The contrast in this depletion of stored food was quite clear. An examination of the roots was made at the end of fourteen weeks and the total length of the roots of the etiolated plants was found to be about half that of the normal. The crowded and entangled growth of the roots of the normal plant was in marked contrast to that of the etiolated. A number of buds on the basal portion of the etiolated stems, including those axillary to the cotyledons, started into activity, but those of the normal stem remained dormant.

The cross-section of the middle portion of the normal stem (plate 4, figure 1) showed a fairly well developed woody cylinder about 300 μ thick, with definite cambium and numerous vessels in the wood. The bast-bundles were 48 in number, composed of lignified cells with laminae 3.5–4 μ thick, interspersed at times with unlignified, thin-walled cells; occasionally these latter contained chloroplasts. Usually the secondary bast-bundles were fairly well developed. The remaining cortex consisted throughout of thin-walled cells with a layer of more highly colored cells just without the bast, the whole covered by the unmodified epidermal cells. The cells of the pith frequently contained starch and the perimedullary ring was gorged with starch, as were also the medullary rays. The region of highly colored chloroplasts constituted also a well-marked starch ring at the base of the normal stem.

The cross-section of the etiolated stem (plate 4, figure 2) showed a woody cylinder 150–250 μ thick, consisting of slightly lignified cells, with less conspicuous cambium and with fewer and slightly smaller vessels in the wood. The bast consisted of the same number of bundles but with very slight development of the secondary bundles; the walls were thinner than in the normal and less lignified. The cortex contained fewer chloroplasts than the normal, while the two outer layers of the epidermal system were more or less collapsed and were underlaid by a well-marked hypodermal phellogen. The pith-cells of the etiolated stem were larger than in the normal, while the same gorging of the stems with starch grains was noted in the perimedullary region and in the medullary rays. The earlier formation of phellogen in the etiolated stem may be interpreted as an adaptation to prevent drying out; this phellogen was present near the summit of the etiolated stem. This precocious phellogen formation, in this case with the early collapse of the epidermis, is similar to that observed by MacDougal in *Acer* and *Cornus.**

Etiolated specimens with stems 50 to 60 cm. in length were brought into diffuse illumination near a window and in two months made an additional elongation of about 5 cm. The terminal newly formed portions of such stems bore about 7 normal leaves, with 8 or 10 internodes immediately below still retaining the bract-like organs resulting from etiolation (plate 4, figure 5). The lower portion of the stem, in which precocious development of phellogen had taken place, retained its brown color but was not extended, while the entire upper portion of the stem had become green. Young stems which had made but little growth in darkness made much more rapid growth than that described above for the older stems, and developed an equal crown of normal leaves.

The leaves of the normal plant (plate 4, figure 6) showed a single layer of palisade-cells and no stomata on the upper surface, as before noted by Solereder.† The petioles showed definite cambium, but the vessels gave no lignin reaction. The bract-like hairy leaves of the etiolated plant (plate 4, figures 3 and 4) showed no cambium in petioles, no stomata and no further differentiation of the tissues than an indistinct row of palisade cells, whose length and width were nearly equal.

Rootstocks of *Euphorbia corollata* obtained from Ohio, were also grown in light and darkness under conditions similar to those for *Persea.* No essential difference in the rate of growth, or in the total amount of tissue produced, was observed as between the normal and the etiolated growths of *Euphorbia* (figures *A* and *B*). There was noticeable variation in the thickening of the etiolated stems due to an increase of cortex by activity of the cambium layer.

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* MACDOUGAL, D. T. The influence of light and darkness upon growth and development (Mem. N. Y. Bot. Gard. 2:) 97–100, 188–190. 1903.

† SOLEREDER, H. Systematische Pflanzenanatomie 774. 1900.

The determination of the water and dry matter in the stems of these specimens gave the following results:

DRY SUBSTANCE IN STEMS OF *Euphorbia corollata*

	Normal plant per cent.	Etiolated plant per cent. I	Etiolated plant per cent. II	Etiolated plant per cent. Average.
Water	86.90	91.11	89.63	90.37
Dry substance	13.10	8.89	10.37	9.63

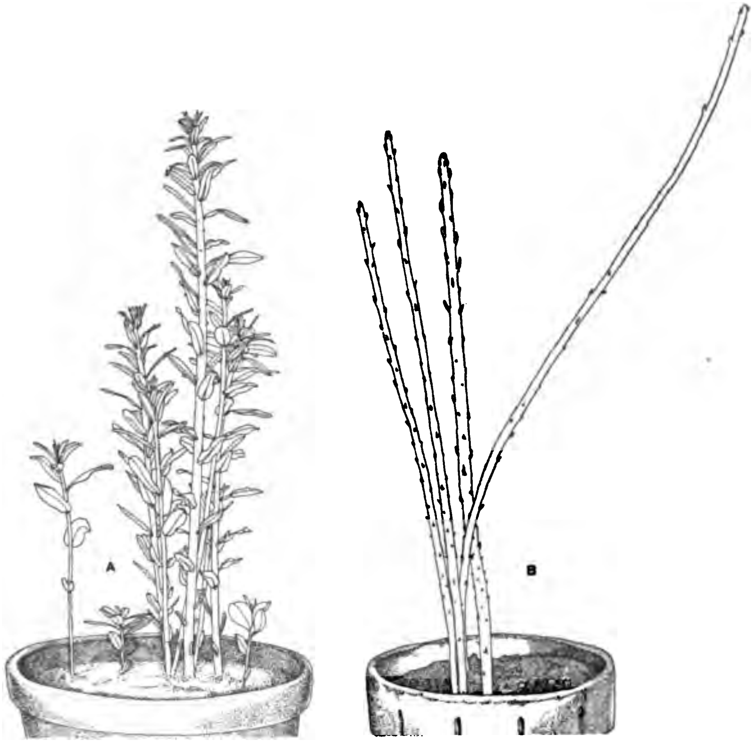


FIGURE A. Normal plant of *Euphorbia corollata*.
FIGURE B. Etiolated plant of *Euphorbia corollata*.

A transverse section of the stems showed (plate 5, figure 1) in the normal a rather feeble development of the strengthening tissue and a cambium of several layers of short cells. The woody parts of the cylinder were irregularly and feebly developed, bringing the groups of vessels into great prominence. The etiolated stem, as before stated, showed (plate 5, figure 2) a tendency to develop cortical parenchyma and the woody portion scarcely less developed than in the normal. These differences will be evident in the illustrations (plate 5, figures 1 and 2). Referring to the analysis it is observed that the increase in the thickness of the etiolated stems has not been accompanied by any considerable increase of solid matter and that the etiolated plant contains about 3½ per cent. more water than the normal. These results are in harmony with those previously obtained by others.

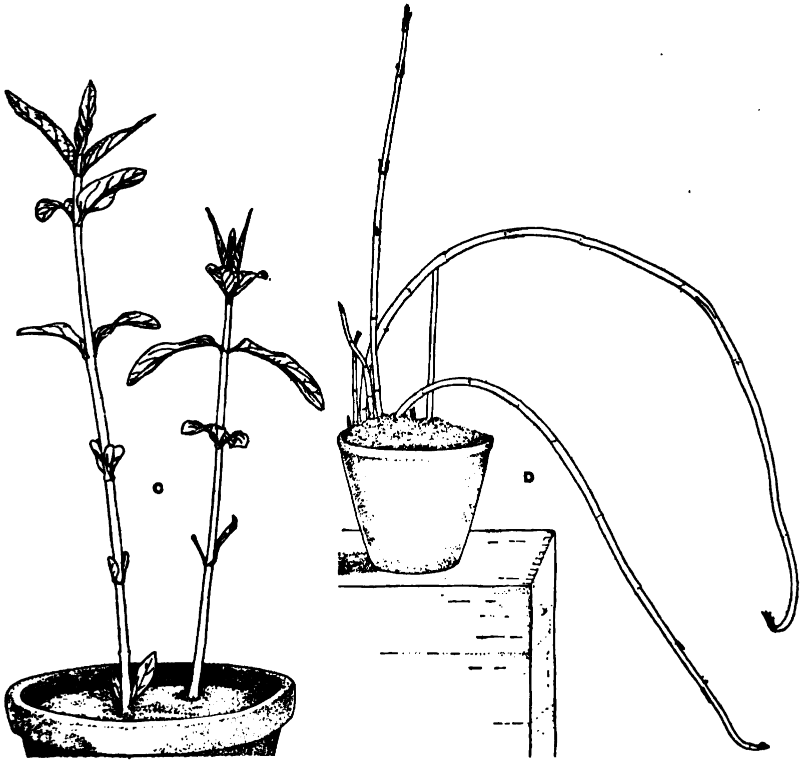


FIGURE C. Normal plant of *Asclepias incarnata*.
FIGURE D. Etiolated plant of *Asclepias incarnata*.

Roots of *Asclepias incarnata* were likewise collected at Wooster, and plants grown from them in the etiolating chamber and the propagating house of the New York Botanical Garden. The etiolated plants of this milkweed started to grow earlier than the normal, and produced longer stems (figures *C* and *D*). These developed as many as 13 or 14 internodes, with a length varying between 5 and 12 cm. The lower axillary buds of the etiolated plants showed a tendency to start into activity during the growth of the main stem. The leaves were dropped from the etiolated stems, so that when the examination was made none were found below the tenth or twelfth internodes from the base; although in a few instances bract-like organs formed on lower internodes were retained for a long time. Normal stems of the same age produced but 7 to 9 internodes with an average length of 3–4 cm. It would appear from these facts that the abnormal length of the etiolated stems of this plant is due both to the exaggerated growth of the internodes and to the actual multiplication of the internodes.

The anatomical features present some interesting comparisons which may be studied by reference to the figures. In the etiolated stems (plate 5, figure 6) the cambium included four or five layers, while the woody cylinder and the bast-cells were less strongly developed than in the normal, as might have been expected. In the middle of the normal stem it was noted that the bast-sheath was more nearly continuous than at the base; a like condition, though less strongly marked, was also observed in the middle of the etiolated stem. In one instance an etiolated stem had become nearly prostrate by its own weight, and the apical portion had responded by an apogeotropic curvature which brought the tip into an erect position. Little difference could be detected in the structure of the central cylinder of these stems with respect to the convex sides, but the bast-fibers, scarcely differentiated on the convex side, were developed as well-marked strands composed of colums of two or three dozen cells in cross-section upon the opposite or concave side. This seems to show that while stretching tension might induce the development and differentiation of this tissue, the absence of stress, or positive compression resulted in the non-differentiation. Similar effects have been noted in special investigations, by various workers, dealing with the effect of compression and tension upon the mechanical tissues. Determinations of water were made in the normal and etiolated stems of this plant with the following results:

DRY SUBSTANCE IN PLANTS OF *Asclepias incarnata*

	Normal plant per cent.	Etiolated plant per cent. I	II	Average.
Water	86.58	91.83	91.57	91.70
Dry substance	13.42	8.17	8.43	8.30

Here we have wider divergence amounting to more than 5 per cent. difference in the dry substance of the normal above that of the etiolated stems.

Rootstocks of *Euphorbia Cyparissias* were brought from Wooster, Ohio, to the New York Botanical Garden, and after these had shown signs of activity were placed in suitable pots and some exposed to light while others were placed in the etiolating chamber, on March 20, 1903. The new stems were one to two cm. in height although none had formed chlorophyl to any noticeable extent. One month later the stem-lengths of the normal and etiolated plants were respectively 8 to 10 cm. for the normal and 6 to 8 cm. for the etiolated. It is evident that this plant does not support the assumption that light exercises an actual retarding effect upon growth.

Roots of *Apocynum cannabinum* were lifted and potted in November, 1902, and at this time duplicate pots were placed in the dark chamber and in the propagating house of the Garden; a large number of duplicates were cared for in the propagating house. The plants showed little tendency to make early growth in either situation. Toward the end of April, 1903, shoots began to appear on the plants in the dark chamber and a corresponding plant was set aside in the propagating house. In June, 1903, measurements were kindly taken by Dr. W. A. Cannon, laboratory assistant at the New York Botanical Garden. The etiolated plants attained a height of about 30 cm., while the normal specimens made no marked growth after having been set aside in April.

Similar results to those of *Apocynum* were obtained with roots of *Asclepias syriaca*. In this case the etiolated specimen attained a height of 30 cm. while the normal plant attained a length of but 5 to 6 cm., development being arrested for some reason.

Interpretation of results

It is evident from the foregoing that the phenomena of etiolation are not in themselves to be regarded as of a useful adaptive character, as put forward by many writers on the subject. In some instances it is conceivable that the undue elongation of stems that ensues might serve the useful purpose of carrying the apical part of the stem with its leaves past an obstruction intercepting the light, but a census of the species which have been subjected to etiolation by MacDougal and others shows that less than half exhibit such elongations.

An important correlation-reaction is shown by the basal buds of etiolated stems. Numbers of such buds usually dormant are awaked in darkness and develop stems.

None of the facts derived from the study of the behavior of etiolated plants may be construed to indicate that light exercises a retarding effect on growth, however. If such a conclusion is to be maintained it must be justified on other grounds beside the results of studies of the action of plants in darkness.

A consideration of the structure of the plants studied in the work described above leads to the conclusion that when grown in darkness the tissues do not attain full development and that the differentiations by which the separate tissues are distinguished appear to be carried out only partially or not at all. The degree of incompleteness depends to some extent upon the organographic relations of the structures taken into consideration. This failure in the perfection of the tissues, which may even include their non-appearance, is very naturally coupled with a prolonged growth of the meristematic cells which by repeated division may thus increase either the thickness or the length of a stem.

Directly and indirectly, light seems to exert a stimulative effect upon the morphogenic processes leading to the differentiation of the tissues. If an etiolated shoot is brought into illumination, the portions in which the embryonic tissue has not gone beyond a certain age carry on development approximating the normal. Older etiolated tissues may form chlorophyl or undergo additional thickening of the walls, but no other differentiations in form are possible.

The formation of prosenchymatous cells in the concave side of a geotropically curving stem of *Asclepias*, in which they were lacking from the opposite convex side, is an excellent example of pure mechanical induction. In normal stems the development must set up, through the tension of the various tissues of the stem, stimuli which would induce the formation of prosenchyma regardless of the action of light. Now in the etiolated stem the bast-strands seem to be induced only by the bending strains exerted on the stems by their tendency to fall over, and the stresses throughout the stem are otherwise equal, being simply those arising from turgidity. When such a stem is laid in a prostrate position and the embryonic cells of the apical portions of the stem produce a curvature in making an adjusting response, the stretching tension set up in the concave side of the stem acts as a stimulus inducing the formation of the mechanical tissue as described.

The writer wishes to express his great obligations to Dr. D. T. MacDougal, Director of the Laboratories of the Garden, for material aid and constant encouragement in the course of this work, and to make further acknowledgment of special assistance in the interpretation of results. The illustrations are chiefly from drawings made by A. Mariolle, of the Garden, to whom his best thanks are due.

OHIO AGRICULTURAL EXPERIMENT STATION.

Explanation of plates 4 and 5

PLATE 4

Persea gratissima

FIG. 1. Portion of cross-section of middle of stem of normal plant.

FIG. 2. Portion of cross-section of middle of stem of etiolated plant.

FIGS. 3, 4. Bract-like hairy leaves of etiolated plant, × 4½.

FIG. 5. Etiolated 10-weeks' seedling (same as figure 7), after two months' illumination, about one-fifth natural size.

FIG. 6. Leaf of normal plant, about one-half natural size.

FIG. 7. Etiolated 10-weeks' seedling, about one fifth natural size.

PLATE 5

Euphorbia corollata

FIG. 1. Portion of cross-section of stem of normal plant.

FIG. 2. Portion of cross-section of stem of etiolated plant.

FIG. 3. Leaf of normal plant, two thirds natural size.

FIGS. 4, 5. Leaves of etiolated plant, × 1⅓.

Asclepias incarnata

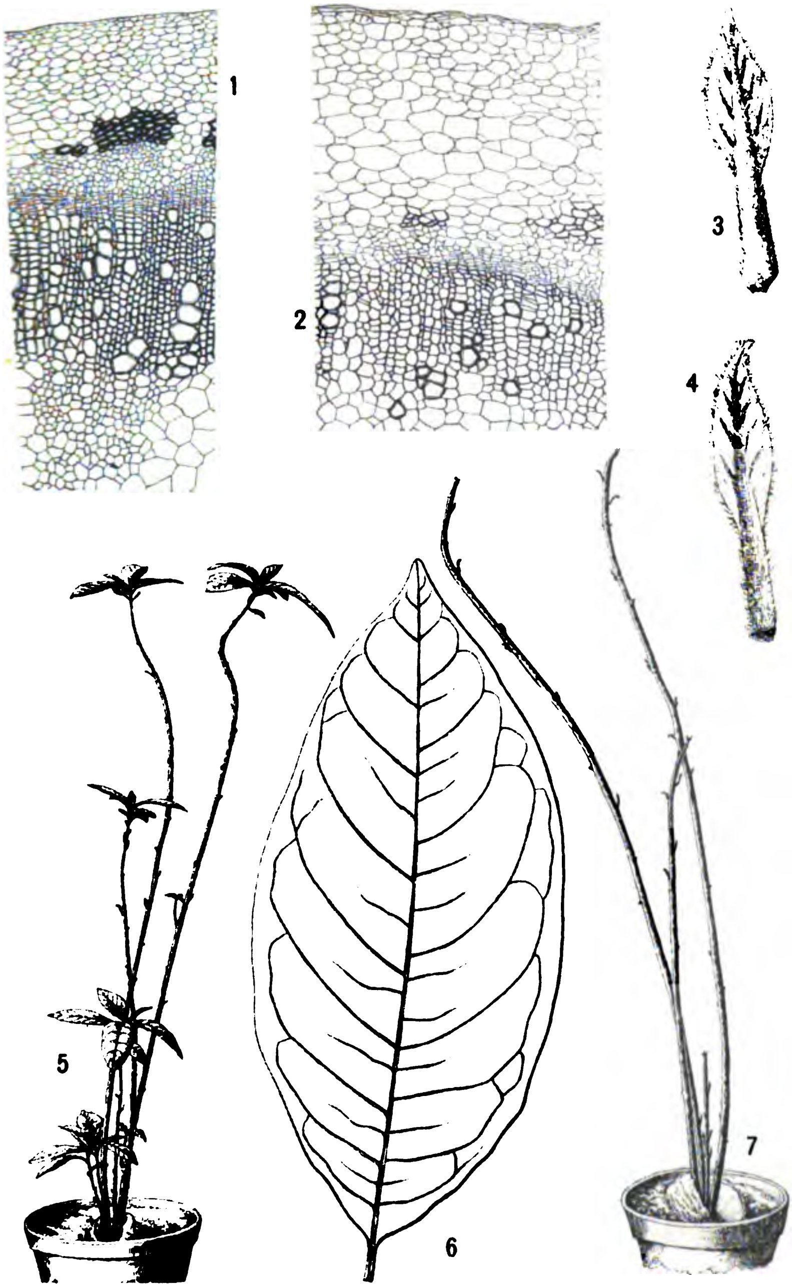
FIG. 6. Portion of cross-section of middle of stem of etiolated plant.

FIG. 7. Portion of cross-section of middle of stem of normal plant.

FIG. 8. Portion of cross-section of concave side of curved stem of etiolated plant.

FIG. 9. Portion of cross-section of convex side of curved stem of etiolated plant.

FIG. 10. Leaf of etiolated plant, × 1⅓.



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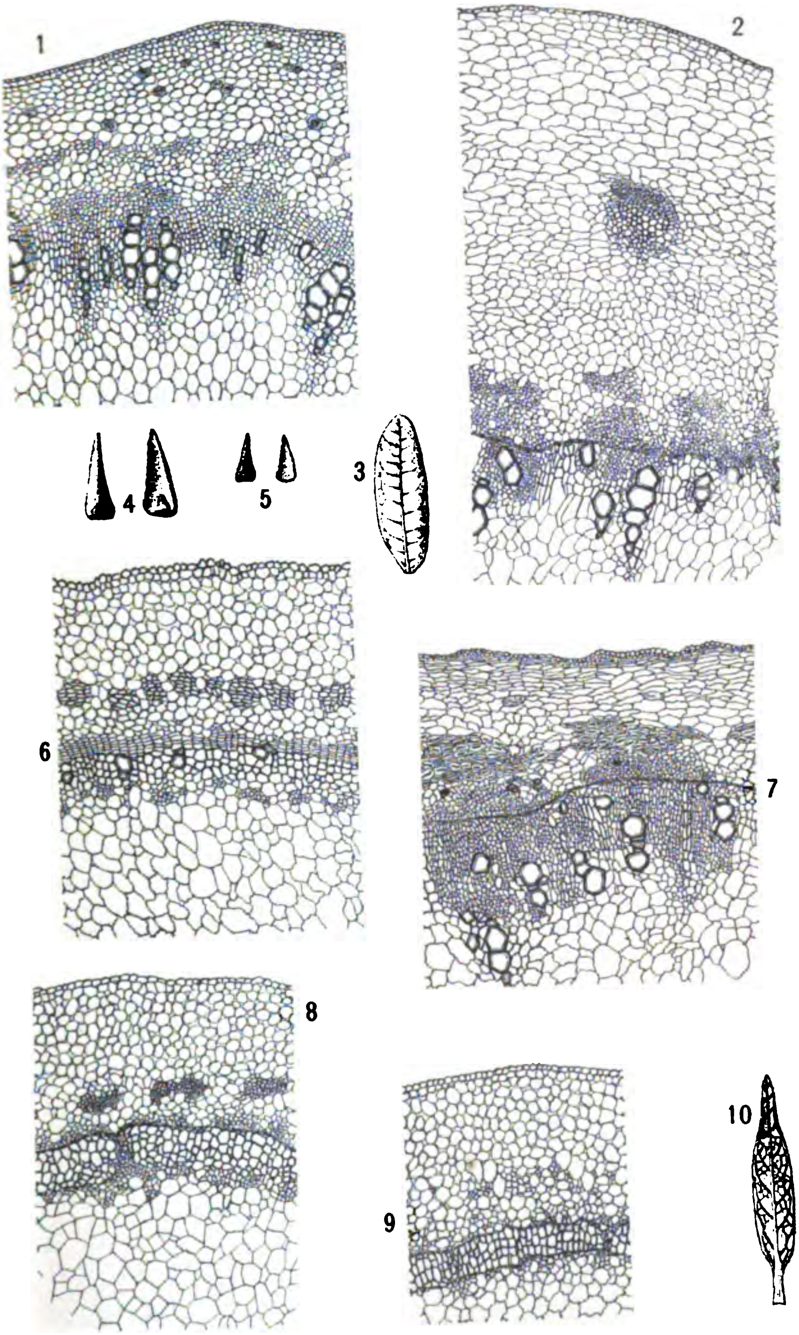

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STUDIES ON THE ROCKY MOUNTAIN FLORA—XVI

By PER AXEL RYDBERG

NEW YORK
1906

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 33: 137-161. 1906]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 33 : 137–161. 1906.]

Studies on the Rocky Mountain flora — XVI

PER AXEL RYDBERG

Salix Watsonii (Bebb) Rydb.

Salix cordata Watsonii Bebb, Bot. Calif. **2**: 86. 1880.

Salix flava Rydb. Bull. Torrey Club **28**: 273. 1901. Not *S. flava* Schoepf. 1796.

Chenopodium oblongifolium (S. Wats.) Rydb.

Chenopodium leptophyllum oblongifolium S. Wats. Proc. Am. Acad. **9**: 95. 1873.

Atriplex subspicata (Nutt.) Rydb.

Chenopodium subspicatum Nutt. Gen. Am. **1**: 199. 1818.

Atriplex patula subspicata S. Wats. Proc. Am. Acad. **9**: 107. 1873.

Rumex praecox Rydb. sp. nov.

Perennial with a thick fleshy rootstock; stem 2–3 dm. high, striate; basal leaves petioled, rather thick; petioles 5–10 cm. long; blades oval or elliptic, 4–10 cm. long, 2–4 cm. wide, rounded at both ends; stem-leaves similar, but smaller, short-petioled and more acute; flowers perfect, in terminal and axillary panicles; perianth-lobes oval, rounded at the apex; the outer 1.5 mm., when fully developed about 3 mm. long, the inner 3–5 mm., without tubercles; fruit developed before the perianth-lobes become much enlarged, shining.

This species is related to *R. occidentalis*, but is characterized by its fleshy tuber-like rootstocks and its precocious fruiting.

COLORADO: Grayback mining camps, 1900, *Rydberg & Vreeland 6328* (type); Bob Creek, La Plata Mountains, 1898, *Baker, Earle & Tracy 270.*

Paronychia brevicuspis (A. Nels.) Rydb.

Paronychia sessiliflora brevicuspis A. Nels. Bull. Torrey Club **26**: 237. 1899.

LIMNIA L. (Kongl. Sv. Vet. Ak. Hand. **1746**: 130. 1746); Haw. Syn. Pl. Succ. 11. 1812.

Greene, Howell and Robinson have transferred a number of species from *Claytonia* to *Montia*; but none of them has given any obvious reason. Dr. Greene satisfied himself by transferring the sections ALSINASTRUM, NAIOCRENE and MONTIASTRUM. These evidently come nearest to *Montia* of all the sections of *Claytonia*. Prof. Howell, followed by Dr. Robinson, also transferred the section LIMNIA, and the rhizomatous species of EUCLAYTONIA of Gray. The difference between the two genera *Claytonia* and *Montia* as now limited is practically reduced to the number of ovules; 6 in the former, 3 in the latter. In *Montia* we find now both regular and irregular flowers, free petals and partly united petals, 5 stamens and 3 stamens, opposite stem-leaves and alternate stem-leaves, annuals and perennials, and of the latter several kinds, viz., with horizontal rootstocks, with short stolons bearing offsets, with slender runners bearing cormlets at the ends, or with axillary bulblets. In the olden time, *Montia* was easily distinguished from *Claytonia* by its gamopetalous corolla cleft on one side. It may be that all the sections mentioned above should be removed from *Claytonia*, but they should not be transferred to *Montia*, making this genus more unnatural than *Claytonia* ever was. I think that in a family like *Portulacaceae*, in which the modifications in the flowers are so slight, generic characters should to some degree be sought in the general habit. Instead of transferring the sections to *Montia* it would have been better to restore the Linnaean genus *Limnia* (which was adopted by Haworth), and to include in it all the American species of *Montia*, except *M. fontana*; or else to continue the splitting and propose several new genera. The typical Rocky Mountain species of *Limnia* are the following:

Limnia asarifolia (Bong.) Rydb.
Claytonia asarifolia Bong. Veg. Sitcha 137. 1831.

LIMNIA SIBIRICA (L.) Haw. Syn. Pl. Succ. 11. 1812.
Claytonia sibirica L. Sp. Pl. 204. 1753.

Limnia arenicola (Henderson) Rydb.
Claytonia arenicola Henderson, Bull. Torrey Club **22**: 49. 1895.

LIMNIA PERFOLIATA (Donn) Haw. Syn. Pl. Succ. 11. 1812.

Claytonia perfoliata Donn, Ind. Hort. Cantab. 25. 1796. — Willd. Sp. Pl. **1**: 1186. 1798.

Limnia depressa (A. Gray) Rydb.

Claytonia parviflora depressa A. Gray, Proc. Am. Acad. **22**: 281. 1887.

Limnia parviflora (Dougl.) Rydb.

Claytonia parviflora Dougl.; Hook. Fl. Bor. Am. **1**: 225. 1832.

At least two of the species of *Claytonia* transferred to *Montia* are, however, so unlike the rest that they can not very well be included in *Limnia*, but are better regarded as types of distinct genera.

CRUNOCALLIS Rydb. gen. nov.

Procumbent or decumbent water or mud-plants, rooting at the nodes and producing long runners, which develop small globose cormlets at the apex. Leaves several pairs, opposite. Sepals two, nearly equal. Corolla regular. Petals 5, similar and equal. Stamens 5. Ovary 3-ovuled. Capsule 1–3-seeded. Seeds granular-muriculate.

This genus has the flowers of *Claytonia*, but the general habit of *Montia*; the mode of propagation and the seeds are different from both.

Crunocallis Chamissonis (Ledeb.) Rydb.

Claytonia Chamissoi Ledeb.; Spreng. Syst. **1**: 790. 1825.

NAIOCRENE (T. & G.) Rydb. gen. nov.

Claytonia § *Naiocrene* T. &. G. Fl. N. Am. **1**: 201, in part. 1838.

Sarmentose, spreading or decumbent plants, with alternate fleshy leaves, bearing bulblets in their axils. Sepals very unlike, one broad and 2-lobed at the apex. Corolla regular or nearly so. Stamens 5. Ovary 3-ovuled. Seeds 1-3, shining.

Naiocrene parvifolia (Moç.) Rydb.

Claytonia parvifolia Moç.; DC. Prodr. **3**: 361. 1828.

EROCALLIS Rydb. gen. nov.

Perennials with globular corms. Radical leaf usually solitary, not present at flowering time. Stem low, with 2 or 3 whorled leaf-like bracts. Sepals 2, somewhat unequal. Petals 3–10, oblong. Capsule oblong-conical, circumscissile.

The genus is closely related to *Claytonia*, and the only distinctive character is the circumscissile capsule. Howell included it in *Oreobroma* and Robinson in *Lewisia;* in both genera, especially the latter, it is out of place on account of its habit.

Erocallis triphylla (S. Wats.) Rydb.

Claytonia triphylla S. Wats. Proc. Am. Acad. **10**: 345. 1875.

Alsinopsis propinqua (Richardson) Rydb.

Arenaria propinqua Richardson, Franklin Journey 738. 1823.

Arenaria verna hirta S. Wats. Bot. King Exp. 41. 1871. Not *A. hirta* Wormskj.

Arenaria verna (a)equicaulis A. Nels. Bull. Torrey Club **26**: 352. 1899.

Alsinopsis Rossii (Richardson) Rydb.

Arenaria Rossii Richardson, Franklin Journey 738. 1823.

Alsinopsis quadrivalvis (R. Br.) Rydb.

Arenaria quadrivalvis R. Br. in Parry 1st Voy. app. cclxxi. 1824.

Alsinopsis obtusiloba Rydb.

Arenaria obtusa Torr. Ann. Lyc. N. Y. **2**: 170. 1827. Not *A. obtusa* All. 1785.

Arenaria biflora S. Wats. Bibl. Index 94. 1878. Not *A. biflora* L. 1767.

Arenaria sajanensis Robinson, Proc. Am. Acad. **29**: 304. 1894. Not *A. sajanensis* Willd. 1816.

Delphinium reticulatum (A. Nels.) Rydb.

Delphinium occidentale reticulatum A. Nels. Bull. Torrey Club **27**: 261. 1900.

ODOSTEMON Raf. Am. Monthly Mag. **2**: 265. F 1818.

Mahonia Nutt. Gen. Am. **1**: 211. 1818.

Both *Odostemon* Raf. and *Mahonia* Nutt. were published in the same year, but the former a few months earlier. The Rocky Mountain species are:

Odostemon Aquifolium (Pursh) Rydb.

Berberis Aquifolium Pursh, Fl. Am. Sept. 219. 1814.
Berberis repens Lindl. Bot. Reg. *pl. 1176.* 1828.
Berberis nana Greene, Pittonia **3**: 98. 1896.

Odostemon nutkanus (DC.) Rydb.

Mahonia Aquifolium nutkana DC. Syst. **2**: 20. 1821.
Berberis Aquifolium Lindl. Bot. Reg. *sub pl. 1176.* 1828.

Odostemon nervosus (Pursh) Rydb.

Berberis nervosa Pursh, Fl. Am. Sept. 219. 1814.

Odostemon Fremontii (Torr.) Rydb.

Berberis Fremontii Torr. Bot. Mex. Bound. 30. 1859.

Lepidium crenatum (Greene) Rydb.

Thelypodium crenatum Greene, Pittonia **4**: 20. 1899.

The species was described from flowering specimens, but the ovaries or young fruit were developed enough to indicate the true genus. Dr. Greene was probably led astray by the fact that the specimens were labeled *Thelypodium integrifolium.*

Erysimum asperrimum (Greene) Rydb.

Cheiranthus asperrimus Greene, Pittonia **3**: 133. 1896.
Erysimum pumilum Rydb. Mem. N. Y. Bot. Gard. **1**: 189. 1900.

In my Flora of Montana I took up Nuttall's *E. pumilum* for this species. This was evidently an error into which I was led by Dr. Greene's discussion in Pittonia, *loc. cit. E. pumilum* Nutt. remains as yet unknown, but from the description it must be a close relative of *E. nivale* and *E. radicatum*, if not one of these species.

Erysimum Bakeri (Greene) Rydb.

Cheiranthus aridus Greene, Pittonia **4**: 198. 1900. Not *C. aridus* A. Nelson. 1899.
Cheiranthus Bakeri Greene, Pittonia **4**: 235. 1901.

Erysimum argillosum (Greene) Rydb.

Cheiranthus argillosus Greene, Pittonia **3**: 136. 1896.

Erysimum amoenum (Greene) Rydb.

Cheiranthus nivalis amoenus Greene, Pittonia **3**: 137. 1896.

Lesquerella stenophylla (A. Gray) Rydb.

Vesicaria stenophylla A. Gray, Bost. Jour. Nat. Hist. **6**: 149. 1850.

This was included in *L. Fendleri* by Dr. Watson, but I think it well distinct.

Euklisia crassifolia (Greene) Rydb.

Streptanthus crassifolius Greene, Pittonia **3**: 227. 1897.

Dr. Greene in Leaflets (**1**: 81–85. D 1904) took up *Euklisia* of Nuttall, only changing its spelling, but he overlooked that it had already been proposed as a genus in Dr. Small's Flora of the Southeastern United States. About three years ago I intended to publish it as a genus, making *Streptanthus cordatus* Nutt. the type. Unfortunately my notes were never published and forgotten. Dr. Small, who had seen them, took up the name in his flora, giving me the credit for the same. As he published only one species, *E. hyacinthoides*, this becomes the type. Dr. Greene took up the name for a group, to which neither Dr. Small's type nor my intended type (which I also think was Nuttall's) belong. If *Streptanthus* should be split up into as many genera as Dr. Greene suggests, neither his species of *Euklisia* nor those known to Nuttall would fall within *Euklisia*. My intention was only to divide the genus into two genera, *Streptanthus* and *Euklisia*. So limited the latter genus will contain the Rocky Mountain species here given.

Euklisia cordata (Nutt.) Rydb.

Streptanthus cordatus Nutt.; T. & G. Fl. N. Am. **1**: 77. 1838.

Euklisia longirostris (S. Wats.) Rydb.

Arabis longirostris S. Wats. Bot. King Exp. 17. 1871.

Streptanthus longirostris S. Wats. Proc. Am. Acad. **25**: 127. 1890.

Peritoma Sonorae (A. Gray) Rydb.

Cleome Sonorae A. Gray, Pl. Wright. **2**: 16. 1853.

Potentilla platyloba Rydb.

Potentilla bipinnatifida platyloba Rydb. Mem. Dep. Bot. Columbia Univ. **2**: 100. 1898.

This is as distinct from *P. bipinnatifida* as most species of *Potentilla* are from their relatives.

Potentilla rubripes Rydb.

Potentilla rubricaulis Rydb. Mem. Dep. Bot. Columbia Univ. **2**: 101. 1898. Not *P. rubricaulis* Lehm. 1830.

Lehmann's species, for which I mistook this Rocky Mountain plant, is the same as *P. prostrata* Rottb.

Argentina argentea Rydb.

Argentina anserina concolor Rydb. Mem. Dep. Bot. Columbia Univ. **2**: 160. 1898. Not *Potentilla anserina concolor* Ser. 1825.

The European plant to which this was referred differs in having more deeply and more sharply toothed leaflets, and smaller flowers.

Fragaria ovalis (Lehm.) Rydb.

Potentilla ovalis Lehm. Ind. Sem. Hort. Bot. Hamb. **1849**: 9. 1849.

Fragaria firma Rydb. Mem. Dep. Bot. Columbia Univ. **2**: 184. 1898.

Dr. Wolf, of Dresden, Germany, has called my attention to the fact that *P. ovalis* Lehm. is no *Potentilla* at all. Prof. Lehmann did not cite any type, but his herbarium shows that it was *Fendler 206*, which I included in *Fragaria firma*.

Fallugia acuminata (Wooton) Rydb.

Fallugia paradoxa acuminata Wooton, Bull. Torrey Club **25**: 306. 1898.

Prunus melanocarpa (A. Nelson) Rydb.

Cerasus demissa melanocarpa A. Nels. Bot. Gaz. **34**: 25. 1902.

The common Rocky Mountain tree is well distinct from the original *Cerasus demissa* Nutt. or *Prunus demissa* Walp. The latter, which was from the Columbia Valley, has thin, very pubescent leaves, and is more related to the eastern *P. virginiana*. *P. melanocarpa* is rather nearer the Mexican species known as *P. Copalin*, and it is sometimes very hard to distinguish it from that species.

ANISOLOTUS Bernh. Sem. Hort. Erf. 1837. — Linnaea **12**: Litt. Ber. 75. 1838.

I think that this genus, well characterized by Bernhardi, should be restored. It is well distinct from the Old World *Lotus* and from *Hosackia*. I think that Dr. Greene's merging all our North American species usually known as *Hosackia* into *Lotus* was very unfortunate, for we do not have any native species which could be included in *Lotus*, even if made broad enough to include *Tetragonolobus* and other Old World genera.

The Rocky Mountain species of *Anisolotus* are:

Anisolotus Wrightii (A. Gray) Rydb.

Hosackia Wrightii A. Gray, Pl. Wright. **2**: 42. 1853.

Anisolotus brachycarpus (Benth.) Rydb.

Hosackia brachycarpa Benth. Pl. Hartw. 306. 1848.
Lotus humistratus Greene, Pittonia **2**: 139. 1890.

Anisolotus rigidus (Benth.) Rydb.

Hosackia rigida Benth. Pl. Hartw. 305. 1848.

Aragallus Hallii (Bunge) Rydb.

Oxytropis Hallii Bunge, Mem. Acad. Sci. St. Petersb. VII. **22**[1]: 162. 1874.

Vicia dissitifolia (Nutt.) Rydb.

Lathyrus dissitifolius Nutt.; T. & G. Fl. N. Am. **1**: 277. 1838.

Lathyrus incanus (Rydb. & Smith) Rydb.

Lathyrus ornatus incanus Rydb. & Smith, Fl. Neb. **21**: 64. 1895.

Chamaesyce flabelliformis (Engelm.) Rydb.

Euphorbia petaloidea flagelliformis Engelm. Bot. Mex. Bound. 185. 1859.
Euphorbia flagelliformis Engelm. Bull. Geol. Surv. Terr. **2**: 243. 1876.

Chamaesyce rugulosa (Engelm.) Rydb.

Euphorbia serpyllifolia rugulosa Engelm.; Millsp. Pittonia 2: 85. 1890.

Chamaesyce albicaulis Rydb.

Euphorbia albicaulis Rydb. Mem. N. Y. Bot. Gard. 1: 266. 1900.

Tithymalus arkansanus coloradensis (Norton) Rydb.

Euphorbia arkansana coloradensis Norton, Rep. Missouri Bot. Gard. 11: 105. 1900.

Sida sagittaefolia (A. Gray) Rydb.

Sida lepidota sagittaefolia A. Gray, Pl. Wright. 1: 18. 1852.

Sphaeralcea marginata York, sp. nov.

Perennial, herbaceous; stem usually branching from the base, with ascending branches, 2–6 dm. tall, densely stellate-canescent; leaf-blades subrotund, rounded-ovate or subcordate, 1.5–4 cm. long, 1.5–3 cm. wide, cordate or truncate at the base, crenate or imperfectly dentate, slightly 3–5-lobed, the middle lobe acute or obtuse, the upper surface with close stellate pubescence, more densely pubescent beneath, petioles less than ½ as long as the blades or sometimes longer; flowers borne in narrow panicles; involucre of 3 small setaceous bracts: calyx-tube densely stellate-pubescent, about 3 mm. long; lobes 5, ovate, acute or acuminate, almost glabrous or sparingly stellate-pubescent on dorsal surface, densely pubescent on the margin, glabrous within, 2–3 mm. long, in fruit 4–5 mm. long; petals pink, obovate, 10–12 mm. long; carpels 10–12 in number, 3–4 mm. long, cuspidate, the lower half reticulated; ovules two; usually only one seed developed in the lower part of each carpel, upper part somewhat aborted; seeds reniform, glabrous.

In general appearance this plant resembles *Sphaeralcea Munroana* (Doug.) Spach; but in the former, the mature carpels separate from the central axis by a small thread attached to the base of each carpel, while in the latter, the carpels do not separate from the central axis by a thread. *Sphaeralcea marginata* also resembles *S. incana* Torr.; but the latter is taller, the leaves are larger, the pubescence on both sides of the leaves is much denser and finer, the paniculate clusters of flowers are longer and more open and the carpels are nearly always two-seeded.

COLORADO: Grand Junction, 1901, *C. F. Baker 93* (type); also 1893, *De Alton Saunders;* McElmo Cañon, 1901, *F. K. Vreeland 860.*

NEW MEXICO: 1901, *F. K. Vreeland 823.*

Cactus similis (Engelm.) Rydb.

Mamillaria similis Engelm. Bost. Jour. Nat. Hist. **5**: 246. 1845.

Mamillaria missouriensis caespitosa S. Wats. Bibl. Index 403. 1878.

Echinocereus aggregatus (Engelm.) Rydb.

Mamillaria aggregata Engelm. in Emory, Notes Recon. 157. 1848.

Echinocereus coccineus Engelm. Wisliz. Rep. 9. 1848. Not *E. coccineus* DC.

Cereus phoeniceus Engelm. Proc. Am. Acad. **3**: 284. 1856.

Echinocereus Roemeri (Muhlenf.) Rydb.

Cereus Roemeri Muhlenf. Allg. Gart. Zeit. **16**: 19. 1848.

Cereus conoideus Engelm. Pac. R. R. Rep. **4**: 35. 1856.

Epilobium adenocladon (Haussk.) Rydb.

Epilobium paniculatum adenocladon Haussk. Mon. Gatt. Epil. 247. 1884.

Anogra latifolia Rydb.

Oenothera pallida latifolia Rydb. Contr. U. S. Nat. Herb. **3**: 159. 1895.

Pachylophus marginatus (Nutt.) Rydb.

Oenothera marginata Nutt.; Hook. & Arn. Bot. Beechey 342. 1838.

Oenothera idahoensis Mulford, Bot. Gaz. **19**: 117. 1894.

Sphaerostigma pubens (S. Wats.) Rydb.

Oenothera strigulosa pubens S. Wats. Proc. Am. Acad. **8**: 594. 1873.

Sphaerostigma minutiflora (S. Wats.) Rydb.

Oenothera alyssoides minutiflora S. Wats. Proc. Am. Acad. **8**: 591. 1873.

CORNELLA Rydb. gen. nov.

The type of the genus *Cornus* L. is *C. mas* L. which has no congener in this country, except perhaps *C. sessilis* Torr. of California. Opiz segregated from *Cornus* the genus *Svida*, to which the European *C. sanguinea* and most of our American cornels belong. Rafinesque in his Alsographia Americana made the genus *Cynoxylon* based on *C. florida* L., and also another genus (or subgenus) *Eukrània* in which he placed *C. canadensis* L. and *C. suecica* L. Unfortunately he made *C. mascula* of Europe, which is congeneric with and some claim the same as *C. mas* L., the type, and *C. canadensis* and *C. suecica* have no available generic name, unless they are included with *C. florida* and *C. Nuttallii* in *Cynoxylon*. Outside of the great difference in habit and fruit between the Dwarf Cornels and the Flowering Dogwoods, the former have one character not found in any of the groups usually included in *Cornus*. The sepals of the Dwarf Cornels have a small horn-like, at last deciduous, spine on the back near the apex. This, together with the peculiar habit, makes them deserve generic rank.

Cornella canadensis (L.) Rydb.

Cornus canadensis L. Sp. Pl. 118. 1753.

Cornella suecica (L.) Rydb.

Cornus suecica L. Sp. Pl. 118. 1753.

Cornella unalaschkensis (Ledeb.) Rydb.

Cornus unalaschkensis Ledeb. Fl. Ross. **2**: 378. 1844.

Pseudocymopterus multifidus Rydb.

Pseudocymopterus montanus multifidus Rydb. Bull. Torrey Club **31**: 574. 1904.

Pseudocymopterus purpureus (C. & R.) Rydb.

Pseudocymopterus montanus purpureus C. & R. Rev. N. Am. Umbell. 75. 1888.

Pseudocymopterus tenuifolius (A. Gray) Rydb.

Thaspium montanum tenuifolium A. Gray, Pl. Wright. **2**: 65. 1853.

Ligusticum montanum tenuifolium S. Wats. Bibl. Index 426. 1878.

Vaccinium oreophilum Rydb.

Vaccinium myrtilloides S. Wats. Bot. King Exp. 209. 1871. Not *V. myrtilloides* Michx. 1803.

Vaccinium Myrtillus A. Gray, Syn. Fl. 2^1: 24. 1878. Not *V. Myrtillus* L. 1753.

The American plant has depressed globular-ovoid corolla, fully as wide as long, while the original European *V. Myrtillus* has ovoid-urceolate corolla, decidedly longer than broad.

Androsace subulifera (A. Gray) Rydb.

Androsace septentrionalis subulifera A. Gray, Syn. Fl. 2^1: 60. 1878.

Dodecatheon sinuatum Rydb.

Dodecatheon radicatum sinuatum Rydb. Bull. Torrey Club **31**: 631. 1904.

Erythraea arizonica (A. Gray) Rydb.

Erythraea calycosa arizonica A. Gray, Syn. Fl. 2^1: 113. 1878.

Anthopogon elegans (A. Nels.) Rydb.

Gentiana elegans A. Nels. Bull. Torrey Club **25**: 276. 1898.

Anthopogon barbellatus (Engelm.) Rydb.

Gentiana barbellata Engelm. Trans. Acad. St. Louis **2**: 216. 1863.

Gentiana Moseleyi A. Nels. Bot. Gaz. **31**: 396. 1901.

Amarella monantha (A. Nels.) Rydb.

Gentiana tenella A. Gray, Syn. Fl. 2^1: 117, in part. 1878.

Gentiana monantha A. Nels. Bull. Torrey Club **31**: 244. 1904.

Amarella plebeia Holmii (Wettst.) Rydb.

Gentiana plebeia Holmii Wettst. Oester. Bot. Zeitsch. **50**: 195. 1900.

Dasystephana Romanzovii (Ledeb.) Rydb.

Gentiana Romanzovii Ledeb.; Bunge, Nouv. Mém. Soc. Nat. Mosc. **1**: 215. 1829.

Gentiana frigida A. Gray, Syn. Fl. 2^1: 120. 1878. Not *G. frigida* Haenke. 1788.

Dasystephana Parryi (Engelm.) Rydb.

Gentiana Parryi Engelm. Trans. Acad. St. Louis **2**: 218. 1863.

Dasystephana affinis (Griseb.) Rydb.

Gentiana affinis Griseb. Gen. et Sp. Gent. 289. 1839.

Dasystephana Forwoodii (A. Gray) Rydb.

Gentiana Forwoodii A. Gray, Syn. Fl. 2^1: 406. [Ed. 2.] 1886.

Dasystephana Bigelovii (A. Gray) Rydb.

Gentiana Bigelovii A. Gray, Syn. Fl. 2^1: 406. [Ed. 2.] 1886.

Dasystephana interrupta (Greene) Rydb.

Gentiana interrupta Greene, Pittonia **4**: 182. 1900.

Frasera scabra (M. E. Jones) Rydb.

Frasera speciosa scabra M. E. Jones, Zoe **4**: 277. 1893.

Frasera stenosepala Rydb.

Frasera speciosa stenosepala Rydb. Bull. Torrey Club **31**: 632. 1904.

Frasera angustifolia Rydb.

Frasera speciosa angustifolia Rydb. Bull. Torrey Club **31**: 632. 1904.

Phlox depressa (E. Nels.) Rydb.

Phlox multiflora depressa E. Nels. Rev. W. N. Am. Phloxes 20. 1899.

Leptodactylon Watsonii (A. Gray) Rydb.

Gilia Watsonii A. Gray, Proc. Am. Acad. **8**: 267. 1870.

Leptodactylon Nuttallii (A. Gray) Rydb.

Gilia Nuttallii A. Gray, Proc. Am. Acad. **8**: 267. 1870.

Phacelia ciliosa Rydb.

Phacelia sericea ciliosa Rydb. Bull. Torrey Club **31**: 636. 1904.

Oreocarya hispidissima (Torr.) Rydb.

Eritrichium glomeratum hispidissimum Torr. Bot. Mex. Bound. 140. 1859.

Oreocarya perennis (A. Nels.) Rydb.

Oreocarya affinis perennis A. Nels. Erythea **7**: 67. 1899.

Mertensia platensis Rydb.

Mertensia polyphylla platensis Rydb. Bull. Torrey Club **31**: 638. 1904.

Agastache pallidiflora (Heller) Rydb.

Brittonastrum pallidiflorum Heller, Bull. Torrey Club **26**: 621. 1899.

Brittonastrum Greenei Briquet, Ann. Conserv. & Jard. Genève **6**: 157. 1902.

Madronella parvifolia (Greene) Rydb.

Monardella parvifolia Greene, Pl. Baker. **3**: 22. 1901.

Madronella dentata Rydb.

Monardella dentata Rydb. Bull. Torrey Club **31**: 641. 1904.

Mentha Penardi (Briquet) Rydb.

Mentha arvensis Penardi Briquet, Bull. Herb. Boiss. **3**: 215. 1895.

Androcera rostrata (Dunal) Rydb.

Solanum rostratum Dunal, Hist. Sol. 234. 1813.

Androcera lobata Nutt. Gen. Am. **1**: 129. 1818.

Pentstemon unilateralis Rydb. nom. nov.

Pentstemon secundiflorus A. Gray, Syn. Fl. **2**^{1}: 263. 1878. Not *P. secundiflorus* Benth.

In Proc. Am. Acad. **6**: 61, Dr. Gray gives *P. secundiflorus* as a synonym of *P. acuminatus* Benth. This was correct as far as Dr. Gray's conception of the latter is concerned. Dr. Gray included in *P. acuminatus* at least four different plants. Of these, two have very broad rounded clasping and abruptly acuminate upper leaves, viz.: the original *P. acuminatus* Dougl. and my *P. cyathophorus*; and two with lanceolate upper leaves, viz.: *P. Fendleri* A. Gray and the original *P. secundiflorus* Benth. Frémont's plant, the type of the latter, is in the Torrey herbarium. On the sheet is written in Dr. Gray's own handwriting: "This is only *P. acuminatus*, Dougl.; small. A. G. 1862." Dr. Gray afterwards transferred the name *P. secundiflorus* to an entirely different plant, describing it in the Synoptical Flora. This therefore needs a new name.

Pentstemon angustifolius caudatus (Heller) Rydb.

Pentstemon caudatus Heller, Minn. Bot. Stud. **2**: 34. 1898.

P. caudatus Heller is in my opinion the southern more luxuriant and broad-leaved form of *P. angustifolius*. The two grade absolutely into each other in Colorado.

Pentstemon trichander (A. Gray) Rydb.

Pentstemon barbatus trichander A. Gray, Proc. Am. Acad. **11**: 94. 1876.

This, as well as *P. Torreyi* Benth., I think should be kept distinct from *P. barbatus* (Cav.) Nutt. of Mexico.

MYZORRHIZA Phil. Linnaea **29**: 36. 1857.

The NOTHAPHYLLON subgenus of *Aphyllon* as limited in Gray's Synoptical Flora has been shifted back and forth between the genera *Phelipaea*, *Anoplanthus* and *Aphyllon*, and has lately been restored to *Orobanche*, where its original species were described. The typical species of *Orobanche* have a bilabiate calyx, while the species here discussed have a 5-parted one. As far as I find, the only genus described to which they can be referred is the one given above. The following two species are found in Colorado:

Myzorrhiza ludoviciana (Nutt.) Rydb.

Orobanche ludoviciana Nutt. Gen. Am. **2**: 58. 1818.

Aphyllon ludovicianum A. Gray, Bot. Calif. **1**: 585. 1876.

Myzorrhiza multiflora (Nutt.) Rydb.

Orobanche multiflora Nutt. Jour. Acad. Nat. Sci. Phila. II. **1**: 179. 1848.

Aphyllon multiflorum A. Gray, Bot. Calif. **1**: 585. 1876.

Galium subbiflorum (Wieg.) Rydb.

Galium trifidum subbiflorum Wieg. Bull. Torrey Club **24**: 399. 1897.

Distegia involucrata (Richardson) Rydb.

Xylosteum involucratum Richardson, Frankl. Journey 733. 1823.
Lonicera involucratum Banks; Spreng. Syst. **1**: 759. 1825.
Distegia nutans Raf. New Fl. Am. **3**: 21. 1836.

Chrysothamnus serrulatus (Torr.) Rydb.

Linosyris serrulata Torr.; Stansbury, Expl. 389. 1852.
Chrysothamnus glaucus A. Nelson, Bull. Torrey Club **25**: 377. 1898.

Chrysothamnus latifolius (D. C. Eaton) Rydb.

Linosyris viscidiflora latifolia D. C. Eaton, Bot. King Exp. 157. 1871.
Bigelovia Douglasii latifolia A. Gray, Proc. Am. Acad. **8**: 646. 1873.

Isócoma Wrightii (A. Gray) Rydb.

Linosyris Wrightii A. Gray, Pl. Wright. **1**: 95. 1852.
Bigelovia Wrightii A. Gray, Proc. Am. Acad. **8**: 639. 1873.

OREOCHRYSUM Rydb. gen. nov.

Plants with slender horizontal rootstock, leafy, viscid-puberulent above. Involucral bracts oblong, pale, rather obscurely 1-ribbed, chartaceous or the outer foliaceous, in about three moderately unequal ranks. Rays several, short. Disc-corollas narrowly trumpet-shaped, deeply 5-toothed. Style-appendages lanceolate, longer than the stigmatic portion. Achenes angled. Pappus white or slightly tawny, of soft scabrous bristles.

When Dr. Greene made his segregations of the old genus *Aplopappus*, he transferred the type of the genus here proposed to *Solidago*, but it is just as much out of place here as among its old associations, *i. e.*, the present genus *Stenotus*. It is true that in general habit it reminds one of a group of species formerly included in *Solidago*, but now segregated as a genus *Oligoneuron* Small; the character of the involucre and the style-appendages, however, distinguish it from *Oligoneuron* as well as from *Solidago* proper.

Oreochrysum Parryi (A. Gray) Rydb.

Aplopappus Parryi A. Gray, Am. Jour. Sci. II. **33**: 239. 1862.
Solidago Parryi Greene, Erythea **2**: 57. 1894.

Solidago pallida (Porter) Rydb.

Solidago speciosa pallida Porter, Bull. Torrey Club **19**: 130. 1892.

Solidago scabriuscula (Porter) Rydb.

Solidago canadensis scabra T. & G. Fl. N. Am. **2**: 224. 1842. Not *S. scabra* Willd.
Solidago canadensis scabriuscula Porter, Mem. Torrey Club **5**: 318. 1894.

Solidago gilvocanescens Rydb.

Solidago canadensis gilvocanescens Rydb. Contr. U. S. Nat. Herb. **3**: 162. 1895.

Aster polycephalus Rydb.

Aster scoparius DC. Prodr. **5**: 242. 1836. Not *A. scoparius* Nees. 1832.

Leucelene serotina (Greene) Rydb.

Leucelene ericoides serotina Greene, Pittonia **3**: 149. 1896.

Leucelene hirtella (A. Gray) Rydb.

Diplopappus ericaefolius hirtella A. Gray, Mem. Am. Acad. **4**: 69. 1849.

Erigeron Wootonii Rydb.

Erigeron cinereus var. γ A. Gray, Mem. Am. Acad. **4**: 68. 1849.

ESCHENBACHIA Moench, Meth. 573. 1794.

Conyza Less. Syn. Comp. 203, in part. 1832. Not *Conyza* (Tourn.) L. 1753.

The type of the Linnaean genus *Conyza* is *Conyza squarrosa* L. but this as well as most of the original species are now included in *Inula*. Lessing transferred the name *Conyza* to an entirely different group of plants. Dr. Greene united our North American species with some species of *Erigeron* into the genus *Conyzella* Rupr.

(1869), which is antedated by *Leptilon* Raf. (1818). Hence *Conyzella* becomes a synonym. I do not think that *Conyza Coulteri* should be included in *Leptilon*, which it resembles in habit but not in the composition of the heads. It has several relatives in Mexico and Central America as well as in the Old World. The oldest available name for these is, if I am not mistaken, *Eschenbachia* Moench.

Eschenbachia Coulteri (A. Gray) Rydb.

Conyza Coulteri A. Gray, Proc. Am. Acad. **7**: 355. 1868.

BERTHELOTIA DC. Prodr. **5**: 375. 1836.

A sericeous composite shrub of the southwestern United States has been variously referred to *Pluchea* and *Tessaria*, but is rather out of place in either genus. It was originally made a genus by itself, *Polypappus*, by America's keenest botanist, Thomas Nuttall, and I think it should have remained a genus distinct from both *Pluchea* and *Tessaria*. It has evidently a congener, however, in the desert regions of the Orient. This was described by De Candolle as *Berthelotia*.

Berthelotia sericea (Nutt.) Rydb.

Polypappus sericeus Nutt. Jour. Acad. Nat. Sci. Phila. II. **1**: 178. 1848.
Tessaria borealis "DC.;" T. & G. in Emory, Notes Recon. 143. 1848.
Pluchea borealis A. Gray, Proc. Am. Acad. **17**: 212. 1882.

Ximenesia exauriculata (Rob. & Greenm.) Rydb.

Verbesina encelioides exauriculata Rob. & Greenm. Proc. Am. Acad. **34**: 544. 1899.

PLATYSCHKUHRIA (A. Gray) Rydb. gen. nov.

Schkuhria § *Platyschkuhria* A. Gray, Am. Nat. **8**: 213. 1874.
Bahia § *Platyschkuhria* A. Gray, Syn. Fl. 2^1: 332. 1884.

The genus *Bahia* as limited in Gray's Synoptical Flora is a rather unnatural one. The group most unlike the rest is the one constituting the section *Platyschkuhria*, which I think deserves generic rank. I adopt the sectional name, although its etymology and form are rather bad.

Platyschkuhria integrifolia (A. Gray) Rydb.

Schkuria integrifolia A. Gray, Am. Nat. **8**: 213. 1874.
Bahia nudicaulis A. Gray, Proc. Am. Acad. **19**: 27. 1883.

Platyschkuhria oblongifolia (A. Gray) Rydb.

Bahia oblongifolia A. Gray, Proc. Am. Acad. **19**: 27. 1883.

Tetraneuris glabriuscula Rydb.

Tetraneuris glabra Greene, Pittonia **3**: 268, in part. 1898. Not *Actinella glabra* Nutt. 1841.

What *Actinella glabra* Nutt. was is not exactly known. It is not, however, the plant for which Dr. Greene adopted the name *Tetraneuris glabra*. If it is a *Tetraneuris* at all, it must be a species related to *T. Ivesiana*, *T. argentea* and *T. leptoclada*, as it is described as having stem-leaves. None of these grows near the original locality of *A. glabra*, viz., Shawnee villages on the Missouri (near Kansas City). The only species that are found within 300 miles from this station are *T. herbacea* Greene of Illinois, and *T. fastigiata* Greene and the following from central and western Kansas. None of these answers the description.

Tetraneuris stenophylla Rydb.

Perennial with a branched caudex, the branches of which are partly subterranean, 2–10 cm. long; leaves basal, very narrowly linear-oblanceolate, 2–4 cm. long, 1–2 mm. wide, strongly punctate, glabrous or with a few long hairs near the base; bases dilated and scarious-margined, only slightly long-hairy; scape 5–10 cm. long, striate, punctate and sparingly strigose; involucre about 5 mm. high and 10 mm. wide, hemispheric; bracts elliptic, obtuse; rays light-yellow, about 10 mm. long and 5 mm. wide, 3–4-toothed and 5–7-nerved.

This is closest related to *T. fastigiata* Greene, in which, however, the bases of the leaves are arachnoid-hairy and the involucres densely villous.

KANSAS: Ford County, 1891, *L. D. Ellis* (type).

COLORADO: Banks of Cimarron, 1860, *Newberry*.

CHAMAECHAENACTIS Rydb. gen. nov.

Cespitose scapiferous perennial, branching below the surface of the ground and with a woody root. Leaves all basal and simple, coriaceous, white-strigose below, sparingly hirsute and punctate above. Involucral bracts about twelve, in two series; the inner series longer and with scarious-margined reddish tips. Corolla flesh-colored, with equal lobes. Stamens included. Style-lips broad. Achenes clavate, densely villous. Pappus of eight nearly equal scales, with prominent midrib and erose tips.

Miss Eastwood, the discoverer of the plant, referred it to *Chaenactis*, to which it is not closely related, resembling this genus only in the color of the corolla. The structure of the fruit and pappus would place it nearer *Bahia* and *Tetraneuris*. In general habit it resembles most that exceedingly rare plant described by Nuttall under the name *Bolophyta alpina*, which by Dr. Gray was tranferred to *Parthenium*.

Chamaechaenactis scaposa (Eastw.) Rydb.

Chaenactis scaposa Eastw. Zoe **2**: 231. 1891.

Rydbergia Brandegei (A. Gray) Rydb.

Actinella grandiflora glabrata Porter, in Port. & Coult. Syn. Fl. Colo. 76. 1874.

Actinella Brandegei Porter; A. Gray, Proc. Am. Acad. **13**: 373. 1878.

Rydbergia glabrata Greene, Pittonia **3**: 270. 1898.

Hymenoxys macrantha (A. Nels.) Rydb.

Picradenia macrantha A. Nels. Bot. Gaz. **28**: 130. 1899.

Hymenoxys Richardsonii macrantha Cockerell, Bull. Torrey Club **31**: 475. 1904.

Evidently Professor Cockerell was correct in uniting *Hymenoxys* and *Picradenia* under the older generic name. To his conception of species I am not willing to assent, however. In this respect I would rather agree with Dr. Greene and Prof. Aven Nelson. The changes in nomenclature of the Colorado species are here given.

Hymenoxys pumila (Greene) Rydb.

Picradenia pumila Greene, Pittonia **3**: 271. 1898.

Hymenoxys Richardsonii pumila Cockerell, Bull. Torrey Club **31**: 472. 1904.

Hymenoxys multiflora (Buckley) Rydb.

Phileozera multiflora Buckley, Proc. Acad. Nat. Sci. Phila. **1861**: 459. 1862.

Picradenia multiflora Greene, Pittonia **3**: 273. 1898.

Hymenoxys chrysanthemoides multiflora Cockerell, Bull. Torrey Club **31**: 507. 1904.

Hymenoxys multiflora Osterhoutii (Cockerell) Rydb.

Picradenia odorata Osterhoutii Cockerell, Bull. Colo. College Mus. 11 D 1903.

Hymenoxys chrysanthemoides Osterhoutii Cockerell, Bull. Torrey Club **31**: 505. 1904.

Achillea alpicola Rydb.

Achillea lanulosa alpicola Rydb. Mem. N. Y. Bot. Gard. **1**: 426. 1900.

Artemisia Scouleriana (Besser) Rydb.

Artemisia desertorum Scouleriana Besser; Hook. Fl. Bor. Am. **1**: 325. 1833.

Artemisia pabularis (A. Nels.) Rydb.

Artemisia rhizomata pabularis A. Nelson, Bull Torrey Club **27**: 34. 1900.

Artemisia viscidula (Osterhout) Rydb.

Artemisia cana viscidula Osterhout, Bull. Torrey Club **27**: 507. 1900.

Carduus filipendulus (A. Gray) Rydb.

Cirsium virginianum filipendulum A. Gray, Man. ed. 5. 273. 1880.

Cirsium filipendulum Engelm.; A. Gray, *loc. cit.*, as a synonym.

Cnicus altissimus filipendulus A. Gray, Proc. Am. Acad. **19**: 57. 1883.

Senecio Flintii Rydb. sp. nov.

Perennial with a cluster of fibrous-fleshy roots; stem about 3 dm. high, striate, sparingly arachnoid-hairy; basal leaves about 8 cm. long; blades orbicular or rounded-oval, abruptly contracted into short petioles, sparingly arachnoid when young, glabrous and rather thick in age; stem-leaves lanceolate, sinuately toothed, auricled and clasping at the base, arachnoid when young; inflorescence small, with 3–6 heads, which are about 1 cm. high; bracts linear, 7–8 mm. long, abruptly acute at the apex, with a triangular black tip; rays light-yellow, broad; achenes striate, glabrous.

Related to *S. exaltatus* and *S. integerrimus*, but differing from the former in the entire basal leaves and small corymb, from the latter in the abruptly acute black-tipped bracts, and from both in the lower stature and the broader basal leaves.

SOUTHWESTERN COLORADO: *W. F. Flint.*

Senecio Harbourii Rydb. sp. nov.

Perennial with a branched caudex; stem 1–2 dm. high, striate, white-floccose, leafy; basal leaves and most stem-leaves petioled, 3–10 cm. long, densely white-floccose; blades oblanceolate or linear-spatulate, entire; uppermost stem-leaves sessile, lanceolate, 1–3 cm. long, more or less auricled at the base; inflorescence corymbiform, with 2–7 heads, which are mostly 10–15 mm. high; bracts narrowly linear, long-attenuate, light yellowish-green and slightly floccose; the calyculate ones minute, subulate; rays bright-yellow, over 1 cm. long and 2 mm. wide; achenes brown, shining, glabrous, angled.

This species is most nearly related to *S. Purshianus* and *S. canus*. From the former it differs in the large heads, longer rays and more leafy stem, and from the latter in the lower habit, narrower and always entire leaves, and the turbinate-campanulate instead of hemispheric heads. It grows in the mountains of Colorado at an altitude of 2700–4000 m., and was first collected by Hall & Harbour.

COLORADO: Mountains south of Ward, Boulder Co., July 18, 1901, *G. E. Osterhout 2424* (type); mountains between Sunshine, and Ward, 1902, *F. Tweedy 4861*; Silver Plume, Aug. 24, 1895, *C. L. Shear 4599*; also at the same date and locality, *P. A. Rydberg.*

Senecio oodes Rydb. sp. nov.

Perennial, with a stout rootstock and caudex; stem 3–4 dm. high, slightly floccose below, branched; basal leaves long-petioled, loosely villous-floccose when young, in age glabrous; petioles

4–9 cm. long; blades thick, oval, 3–6 cm. long, 1.5–4 cm. wide, rounded or obtuse at the apex, abruptly contracted below, coarsely dentate-crenate with triangular-ovate, obtuse teeth; lower stem-leaves similar, the petioles with enlarged toothed or lobed stipule-like bases; the upper short-petioled and narrower; inflorescence corymbiform; heads many, about 1 cm. high; bracts linear, abruptly acute, 5–7 mm. long, slightly villous; rays bright-yellow, 10–12 mm. long, about 2 mm. wide; achenes glabrous, round-angled.

This is perhaps most closely related to *S. cymbalarioides*, but differs in the stouter, more branched and more leafy stem and the large ample stem-leaves. It grows in the higher mountains of Colorado.

COLORADO: Mt. Harvard, 1896, *F. E. Clements 39* (type); Robinson, Aug. 23, 1896, *C. L. Shear 3333*.

Senecio Tracyi Rydb.

Perennial with a short rootstock; stem about 4 dm. high, glabrous; basal leaves glabrous, long-petioled; petioles 3–10 cm. long, slender; blades round-oval or oval, thin, 1.5–5 cm. long, 1–3 cm. wide, entire or merely wavy, rounded at the apex, rounded, truncate or subcordate at the base; stem-leaves lanceolate, acuminate, 2–6 cm. long or the uppermost still smaller, sinuate-crenate, the lower cuneate at the base, the upper auriculate-clasping; inflorescence a small compact cyme; heads 8–11, broadly turbinate, 6–7 mm. high; bracts linear, abruptly acute, glabrous, the calyculate ones subulate, sparingly arachnoid; rays yellow, 6–8 mm. long, about 2 mm. wide.

The species belongs to the *S. aureus* group and is somewhat intermediate between *S. crocatus*, *S. pyrrochrous* and *S. fedifolius*. From the two first it differs in the paler rays and the form of the stem-leaves and from the last in the much larger size and the presence of rays. It grows at an altitude of 3150 m.

COLORADO: Bob Creek, west of Mt. Hesperus, July 1, 1898, *Baker, Earle & Tracy 276*.

Senecio turbinatus Rydb. sp. nov.

Perennial with a cespitose rootstock; stem scapiform, about 1.5 dm. high, more or less floccose; basal leaf-blades cuneate-obovate, thick, 2–3 cm. long, 8–18 mm. wide, loosely floccose when young, dentate above the middle, rounded at the apex, tapering below into petioles about 3 cm. long; inflorescence corymbiform; heads about 4, about 12 mm. high; involucres obconic-turbinate, floccose at the base; bracts linear, gradually acute; rays pale-yellow, 8–9 mm. long, 3 mm. wide.

This species is probably most closely related to *S. pentodontus*, but distinguished by the peculiar involucre, which tapers gradually into the peduncles.

COLORADO: Lake City, 1878, *H. N. Pease*.

Senecio multicapitatus Greenman, sp. nov.

Perennial with a thick woody root; stem 4–10 dm. high, yellowish, glabrous, branched and broom-like, leafy; leaves irregularly pinnately dissected into linear-filiform lobes, 1–1.5 mm. wide, or the upper simple and linear-filiform, somewhat fleshy, glabrous and yellowish-green; heads in a corymbiform inflorescence, numerous, almost cylindric, 7–8 mm. high, about 4 mm. in diameter; bracts 8–10, yellowish, linear, gradually acute, glabrous and shining; calyculate ones small, subulate; rays pale-yellow, 7–8 mm. long and 2 mm. wide; achenes striate, grayish strigose-hispidulous.

This species has been included in *S. Douglasii*, which has long calyculate bracts and is confined to the west coast. *S. multicapitatus* resembles closely *S. Riddellii* in habit, but differs in the narrow heads and few bracts. In *S. Riddellii* the bracts are 12–15 and the involucre campanulate. *S. multicapitatus* grows on plains and in mountain valleys of Colorado, New Mexico, and Arizona.

COLORADO: Huerfano Valley, near Gardner, 1900, *F. R. Vreeland 651;* Mt. Princeton Station, 1901, *Underwood & Selby 465*.

NEW MEXICO: Gray, Lincoln Co., *F. S. Earle & Ester S. Earle;* high plains north of El Capitan Mountains, *F. S. Earle & Ester S. Earle 388*.

ARIZONA: Holbrook, 1896, *Myrtle Zuck*.

PRENANTHELLA Rydb. gen. nov.

Low diffusely branched annuals, with numerous small heads terminating the branches. Lower leaves ample, oblong or spatulate in outline, more or less runcinate; the upper reduced and bract-like. Involucres oblong, 4–5-flowered with as many oblong bracts and 1 or 2 small calyculate ones. Achenes gradually tapering downward from the truncate summit, 4–5-ridged. Pappus of white soft capillary bristles.

The species on which this genus is based was first described as a *Prenanthes* and later transferred to *Lygodesmia*. It is so unlike the other species of *Lygodesmia* in habit, that the habit alone would suggest a distinct genus. But the best character is found in the achenes, which are ribbed and tapering downward from the summit instead of upwards from the base. The fruit agrees better with that of *Nabalus* (*Prenanthes*), but from this genus *Prenanthella* is distinguished by the habit and the structure of the involucre.

Prenanthella exigua (A. Gray) Rydb.

Prenanthes exigua A. Gray, Pl. Wright. **2**: 105. 1853.
Lygodesmia exigua A. Gray, Proc. Am. Acad. **9**: 217. 1874.

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THE HEMLOCK GROVE ON THE BANKS OF THE BRONX RIVER AND WHAT IT SIGNIFIES

BY DR. N. L. BRITTON

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THE HEMLOCK GROVE ON THE BANKS OF THE BRONX RIVER AND WHAT IT SIGNIFIES.

The forest of Canadian hemlock spruce along the Bronx River, within the portion of Bronx Park set apart for the New York Botanical Garden, is one of the most noteworthy natural features of the Borough of the Bronx, and has been characterized by a distinguished citizen as " the most precious natural possession of the city of New York." I shall attempt to describe it in some detail and to indicate the relationship of this hemlock spruce, commonly known in America as hemlock, to other evergreen trees; to indicate its natural geographical distribution, trace its history, and discuss its uses.

This forest exists in the northern part of Bronx Park on the banks of the river and their contiguous hills; its greater area is on the western side of the stream, but it occupies a considerable space on the eastern side above the Lorillard Mansion and below the " Blue " bridge. The area west of the river extends from just above the " Blue " bridge down stream to a point nearly opposite the old Lorillard Snuff Mill, and is the part commonly designated " Hemlock Grove." Its total length along the river is approximately 3,000 feet; its greatest width, 900 feet, is at a point on the river about 700 feet above the water fall at the

Lorillard Mansion. The total area occupied by the trees on both sides of the river is between thirty-five and forty acres.

While this area is mostly covered by the hemlock spruces, and although they form its predominant vegetation, other trees are by no means lacking; beech, chestnut, sweet birch, red maple, hickory, oaks, dogwood, tulip-tree, and other trees occur, and their foliage protects the hemlocks from the sun in summer to a very considerable extent; there are no coniferous trees other than the hemlocks, however, within the forest proper. The shade is too dense for the existence of much low vegetation, and this is also unable to grow at all vigorously in the soil formed largely of the decaying resinous hemlock leaves; it is only in open places left by the occasional uprooting of a tree or trees by gales that we see any considerable number of shrubs or herbaceous plants, their seeds brought into the forest by wind or by birds. In fact, the floor of the forest is characteristically devoid of vegetation, a feature shown by other forests of hemlock situated further north. The contrast in passing from the hemlock woods to the contiguous hardwood area which borders them to the west and north, toward the museum building and the herbaceous grounds, is at once apparent, for here we see a luxuriant growth of shrubs and of herbs, including many of our most interesting wild flowers.

The seeds of many kinds of plants growing outside the hemlock forest are yearly transported into it by the wind and by birds, but, as I have said, grow very sparingly; the seeds of the hemlock itself do little if at all better; they cannot germinate immediately under the trees which bear them, but spaces exposed to the light are soon occupied by seedling hemlocks, and it is in this way that the forest is perpetuated; young trees may be seen in considerable numbers in places open to the sky along the old paths and trails and along the margins of the forest.

The soil of this forest is in most places thin, often a mere shallow layer immediately upon the gneissic and schistose rocks which underlie it, composed of the decaying particles of the rocks and of the rotted products of countless annual leaf-falls; the roots of the trees accommodate themselves to this condition, lengthening in all directions in their search for food, and often assuming unusual and sometimes grotesque forms in penetrating crevices, or exposed where the rain has washed the soil away. A capital illustration of this was to be seen several years ago when a giant tree was uprooted during a violent storm; it had scarcely any soil under it, coming away and leaving the rock bare over several square yards, but its roots reached many feet all around and it had been anchored by some of them penetrating cracks in the rock; otherwise little energy would have been needed to fell it. This soil, composed so largely of natural leaf-mould, is annually enriched in the autumn by the leaf-fall from oaks, chestnut, birch, and the other deciduous trees, and again in the spring by the leaves of the hemlock itself, which persist over winter and do not fall away to any extent before the new growing season commences; this is nature's method of replenishing forest soils, and any interference with it jeopardizes the food supply of the trees and consequently endangers their health and vigor; they thus obtain naturally much of their food from their own products of previous years, and therefore it is not good practice to rake up leaves within the forest.

And, if I may be permitted to disgress, all natural woodlands should be treated in accordance with this policy of let alone. Artificial plantations in parks and on lawns cannot always be so maintained, from practical considerations, but the food removed by raking off fallen leaves should be replaced at intervals by means of fertilizers of one kind or another, giving back to the soil those chemical substances which the trees and shrubs are annually taking from it, otherwise the soil will be impoverished. The vigorous growth of trees is quite parallel with that of any other crop raised on the soil, and no intelligent farmer would permit his farm to go long without manure.

A large part of the Bronx hemlock forest may safely be regarded as primeval, and this consideration is one of the most interesting facts connected with it, because tracts of virgin woodland are few and far between in the vicinity of New York. Doubtless individual trees were cut from it in former times, but never sufficient to prevent its continuance. The Lorillards, who held this land for many years before it was taken for park purposes by the city, carefully protected the woodland, and the thanks of the present and of future generations are due them for its preservation; it was evident to the commission in charge of selecting areas for the great park system of the Bronx that this preservation should be continued, and their action in securing this land for public enjoyment and instruction was timely, for its increase in value, due to the northward growth of the city, became an incentive to the proprietors to realize its monetary value, and it was, indeed, at one time surveyed and laid out for streets and building lots, as is evidenced by the numerous granite monuments sunk in the ground; a greater misfortune to the city than the carrying out of this proposition can scarcely be imagined, and it is a great satisfaction to know that it was averted. The only dangers to which the forest can now be exposed are vandalism or the thoughtless starting of fires, and these it is earnestly sought to prevent by frequent patrolling, but the number of people in the community bent on mischief would be a surprise to you all if it could be accurately estimated. To further ensure the safety of the forest, it will doubtless be necessary to adopt measures looking toward the restriction of travel through it to well defined lines, by indicating the existing paths and trails; the thin soil and the consequent proximity of the tree roots to the surface cause indiscriminate tramping over them by multitudes to be undesirable. The parks and gardens of the Bronx are already visited by considerable numbers of people, but when these numbers are very largely increased, as they certainly will be, the policing problem, already acute, will become far more serious.

The hemlock spruce is one of the most beautiful of American evergreen trees, the delicate graceful spread or slight droop of its twigs being quite characteristic of it as compared with its relatives the firs and true spruces, and the density of its shade is unexcelled. The trunk rises as a noble column, sometimes attaining a height of 110 feet with a diameter just above the base of four feet; growing undisturbed and not crowded by other trees, its lower branches clothe the trunk quite to the ground, but such magnificent specimens are seldom seen, because it is typically a tree of groves and forests, and one half or two thirds of the trunk is usually bare of branches; the reddish bark, sometimes tinged with purple, becomes three fourths of an inch thick, that of old trees ridged and furrowed; the inner layers of the bark are astringent, and it is used in large amounts for tanning leather, sometimes mixed with oak bark; it is the most important economic product of the plant, many thousands of trees being annually felled in the northern states and Canada for this purpose; a fluid extract of the bark is used in pharmacy as an astringent. The wood is light in weight, its specific gravity when entirely dry being only 0.42, a cubic foot of it weighing but twenty-six pounds; it is light brown or nearly white in color, soft, weak, coarse-grained, and not very durable. It furnishes a coarse and cheap lumber largely used as boards in building houses and other structures, and for some other special purposes; it contains a resin known as Canada pitch, obtained by boiling the wood and bark especially taken from the round knots, which was formerly used in pharmacy as the basis of plasters, but it is not now utilized to any considerable extent. The leaves are small and narrow, averaging a little more than half an inch in length and rather less than one-twelfth inch in width; they are dark green on the upper side, but quite pale green or whitish on the lower surface; they spread like the barbs of a feather in one plane; the new ones appear on the twigs in the spring and are then bright green, the tips of the twigs nodding; they persist on the twigs through parts of three seasons, falling away in the spring; like other "evergreen" trees, the hemlock spruce is evergreen because it is never bare of leaves, not the same leaves, however. The flowers, as in all conebearing trees, are small, of two kinds, and borne in small, dense clusters, appearing in April or May; the clusters of staminate flowers, those containing the pollen grains, are found in the axils of the leaves, the clusters of pistillate flowers are at the ends of the twigs, and after their fertilization by the pollen from the staminate flowers, ripen into the cones; these are oblong, nodding, blunt, a little longer than the leaves, composed of numerous thin appressed scales, and under each scale is another scale which carries the small seeds.

As observed by MacDougal (see *Journal,* New York Botanical Garden 1: 97) germination of the seeds takes place about the middle of May. The little root is provided with a very large root-cap which protects its delicate tissues at the tip as it grows down through the soil; this little root is at first bent, but soon straightens out, carrying the seed, which still contains the minute seed-leaves, up a little in the soil; the coat of the seed is soon cast away and the usually four seed-leaves expand just at the surface of the ground; the plantlet is then seen to consist of a root, seed-leaves, and a little bud immediately above the seed-leaves which at once begins growing and forms the stem, which, if nothing happens to the little plant, develops ultimately into the part of the tree above ground. The trees of the Bronx hemlock forest produce seed very unequally in different years, being apparently entirely barren at times, thus Dr. MacDougal records that no seedlings from seeds produced in 1898 were found, only two could be certainly traceable to the crop of 1897, but an enormous number were produced from the seeds of 1899. As the plantlet grows, close observations of its root will reveal curious clublike thickenings, and these are indispensable to the tree. Microscopic examination shows that they are composed of the densely matted threads of a minute fungus forming a sort of felt on the outside of these little projections. The function of these curious structures, which are known as mycorrhiza, is to absorb food from the soil, and carry it into the rootlets, from which the tree distributes it throughout its stem and leaves. Through this very interesting method of coöperation the hemlock and many other trees receive a large share of their nutrition, and are not healthy if deprived of the mycorrhiza.

The Canadian hemlock spruce was discovered by the earliest European settlers of New England and was well known to them, as appears frequently in their literature, but it seems to have been first botanically noticed by Plukenet, in his Phytographia, published in 1691, where he calls it "Abies minor pectinatus foliis virginiana, conis parvis, subrotundis," and gives a very crude illustration of its leafy twigs and cones. The tree known to him was cultivated in the garden of Bishop Compton in London, who is recorded as having received it from Virginia through John Bannister, a collector of American plants. Philip Miller, writing in 1742, says that this tree had then been destroyed, but that the species had been "retrieved" through seeds sent him from New England, and it soon became well known in European gardens. Linnæus described it in 1763 as *Pinus Canadensis* and it was thus known by many subsequent authors; the French botanist and traveller, Michaux, recognized the tree as more nearly related to the firs, than to the pines, agreeing in this with the opinion of Plukenet, and in 1803 named it *Abies Canadensis,* and this name has also been used for it by many writers. In 1855 Carrière, a distinguished French student of coniferous trees, published a work in which he carefully described all of them known to him, and showed that the hemlock spruces were sufficiently different from both pines and firs to be grouped as a separate genus, to which he assigned the name *Tsuga,* the Japanese name of the hemlock spruce growing in eastern Asia, specifying our tree as *Tsuga Canadensis,* and it has since been known under that name.

The Bronx hemlock forest is the most southern considerable aggregation of these trees near the Atlantic seaboard. A few scattered trees and small clumps or groves grow or have grown naturally at other points in the borough, especially along the Bronx River further north and in the vicinity of Riverdale and elsewhere near the Hudson River; they become plentiful on the sides of valleys and ravines in Westchester County and in western Connecticut, as also in northern New Jersey, and from these regions northward into Canada the hemlock is an abundant forest tree; further west it grows plentifully along the whole Appalachian Mountain system as far south as Alabama, and its extreme western range is found in Minnesota and Wisconsin.

Torrey records in the "Catalogue of Plants Growing Spontaneously within Thirty Miles of the City of New York," published in 1819, that it then grew in woods at Manhattanville, a region long since built over by the advancing city. It also occurred in woods near the extreme northern part of Manhattan Island, opposite Spuyten Duyvil. On Long Island, a few wild trees are recorded from Prospect Park, and others from Suffolk County. A single wild tree only is known in the Borough of Richmond, standing in woods near Arlington. The most southern station in the state of New Jersey is along the Delaware River near Burlington, and the tree is not known to occur in the eastern part of that state from Sandy Hook southward. It will thus be seen that the hemlock spruce is mainly an inhabitant of regions of lower average temperature than that of the Bronx, and its occurrence at our latitude is doubtless governed by local conditions. It is much more abundant and reaches greater dimensions to the north of us and in the mountains; it does not, however, extend northward into the subarctic regions and to the tops of high mountains as the firs and true spruces do, but has its northern limit in Nova Scotia and Ontario and does not ascend the Adirondacks much above 2,000 feet. The immediate relatives of our tree included with it in the genus *Tsuga* are six, three of them North American, and three Asiatic.

1. The Carolina hemlock spruce (*Tsuga Caroliniana*) found in the Alleghany Mountains from southwestern Virginia to South Carolina, differs in having larger cones, the ripe scales of which spread out from the axis, and its branches droop rather strongly; it forms a trunk up to eighty feet in height.

2. The western hemlock spruce (*Tsuga heterophylla*) has cones resting immediately upon the twigs, rather than short-stalked, as in the two eastern kinds, and is the largest of them all, becoming 200 feet high with a trunk ten feet in diameter; it inhabits northwestern America from California to Alaska, forming great forests.

3. The mountain hemlock spruces (*Tsuga Mertensiana*) is a mountain tree ranging from Montana to Washington and southern Alaska; the leaves of this tree are convex on the upper side instead of flat, as in the other American species.

4. The northern Japanese hemlock spruce (*Tsuga diversifolia*) forms mountain forests in central and northern Japan and apparently grows also in China.

5. The southern Japanese hemlock spruce (*Tsuga Araragi*) inhabits southern Japan.

6. The Himalayan hemlock spruce (*Tsuga dumosa*) is a large forest tree of high altitudes in central Asia.

By a glance at a map of the northern hemisphere, we may at once compare the regions inhabited by each of these trees and see their geographical relationships; as we have already shown, they are all either North American or Asiatic. The question at once arises why is there no European member of the genus? In reply, it may be said that there almost certainly has been a hemlock spruce in northern Europe, now extinct, for the study of fossil plant remains of the Miocene epoch, collected on the island of Spitzbergen, indicate that such a tree grew in Tertiary geologic times in the region now occupied by that island, and perhaps elsewhere in northern Scandinavia and Russia.

We now know that plants and animals of such close affinity as to be grouped in the same genus, have in most cases, at least, had a common ancestry; that is to say, all these slightly different hemlock spruces have descended from an ancient hemlock spruce almost certainly as different from any of them as they are different from each other. We also know that the climate of high northern regions was far milder during part of the Tertiary era than it now is, and also that there was complete, or essentially complete, land connection in the Arctic regions between Europe, Asia and North America. Following this warm period there came on very gradually, a long time of intense cold in the northern part of the northern hemisphere, which culminated in the glacial period, when immensely thick sheets of ice and snow covered the continent as far south as Perth Amboy, doubtless forcing all vegetation that was not obliterated to the south. The next great climatical change was a relatively warm wave of great duration, extending, indeed, into our own times, during which the plants and animals not exterminated slowly reoccupied part of their old territory, but the period of time taken by these two migrations was so great that evident changes took place in most of them; thus, instead of the tertiary parent hemlock spruce of Arctic lands, we now have the several different existing ones as its offspring in the north temperate zone.

As to the more distant relatives of the hemlock spruce, we may say that the true spruces, of which there are many kinds, differ in having four-sided leaves spreading in all directions from the twig, and that the firs, also numerous, differ in having their cones erect on the branches instead of drooping. All are natives of the northern hemisphere only, and we have but to go far enough back in geologic times to discover the common ancestry of the whole tribe.

In the collection of coniferous trees of the New York Botanical Garden, the young hemlocks are planted in the space between the elevated railroad approach and the power house; the true spruces are in the area between the conservatories and the station of the Harlem Railroad; the firs are planted on the slope between the conservatories and the driveway to the west.

Our beautiful Bronx forest signifies, then, many things, and it is hoped that this address may lead us all to appreciate, perhaps better then before, the great desirability of its safe and sure preservation, for we will view it not alone as a place of great natural charm, but as possessing educational features of high importance.

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THE POLLEN-TUBE IN SOME OF THE CUCURBITACEAE

By JOSEPH EDWARD KIRKWOOD

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The pollen-tube in some of the Cucurbitaceae *

JOSEPH EDWARD KIRKWOOD

(WITH PLATES 16 AND 17)

In a previous paper on the embryology of the Cucurbitaceae[14] it was the writer's intention to deal with the matters suggested in the present title, but lack of evidence on certain points, and other causes, necessitated their omission at that time. It is hoped here to discover some of the controlling factors in the behavior of the pollen-tube in *Melothria*, *Micrampelis* and *Cyclanthera*, one species of each.

The various phases of the development of the pollen-tube have been studied by numerous writers in widely differing subjects, but until recently little has been done to determine the nature of the influence which directs the pollen-tube in its growth. The conclusions, however, based upon anatomical and experimental evidence, have been by no means unanimous, and much still remains to be done in this field of investigation.

The behavior of the pollen-tube has been seen to vary considerably in different groups. The manner in which it approaches the embryo-sac in different cases has led Pirotta and Longo[27] to recognize three distinct conditions: acrogamy, in which the pollen-tube enters the micropyle, a condition obtaining in the majority of seed plants; basigamy, including those cases in which the tube enters by way of the chalaza, occurring in the Amentiferae; and mesogamy, which thus far has been found in a few cases only and applies to those instances in which the tube enters the nucellus by some other route, *i. e.*, traversing the tissues of the funicle and integuments. Such conditions have been observed in *Cucurbita* and *Alchemilla*.[23]

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In its course from the stigma to the ovule, the pollen-tube may follow a canal through the style where such is available, and intercellular spaces as well, or it may bore through a considerable amount of cellular tissue, which it may or may not affect injuriously. Its course is usually a direct one and the direction of its growth is often influenced mechanically by the structure of the ovary as well as by the distribution of nutritive materials in what has been called conducting-tissue. The influence of the latter as a directing agent has received some attention at the hands of Miyoshi[20],[21] and others whose work we will discuss more fully later, but the results from various sources go to show that in considering the growth of the pollen-tube we are dealing with problems of chemotropic irritability and the action of stimulating substances whose distribution is indicated largely by anatomical features.

While the pollen-tube in angiosperms is ordinarily devoid of branches, a few cases have been observed in which the tube has divided into a number of branches after having reached the ovule. Hofmeister[13], describes the branching of the tubes in *Pothos* and *Hippeastrum*, and in the Amentiferae it has been observed in *Corylus*, *Carpinus*[3], *Juglans*[25], *Hicoria* (*Carya*)[4], *Quercus*[3] and several others. It occurs also in *Cucurbita* as described by Longo[17], and observed by the author. That the branching is associated with the function of absorption has been the accepted view, and the observation of Longo that the branching is in a definite relation to the presence and distribution of starch in adjacent tissues supports this opinion.

Numerous observations have been made on different plants as to the time consumed by the pollen-tube in traversing the distance from the stigma to the embryo-sac. This has been found to vary within wide limits and to be dependent upon no fixed principle except that the immediate approximation of the germ cells is correlated with their degree of maturity. In certain herbaceous plants the time required varies from eighteen hours (*Limnocharis*[12]) to several days (*Crocus*, *Arum*[13]) and even much longer, as in certain orchids, the difference in time being in no relation to the distance traversed. Among woody plants the time between pollination and fertilization has been observed to vary from one month (*Betula*[3]), to several months (*Hamamelis*)[30], and Conrad[7] has shown that it is over a year in *Quercus*. It has been shown that in those cases where a longer time is required the pollen-tube passes through a more or less protracted resting period; in these cases also the branching of tubes is more or less common, as appears in *Pinus* and the other cases above cited.

Another phase of the development at this stage which has not received sufficient attention is the effect of the pollen-tube itself on the formation of the fruit, or the effect in some cases of a mere irritation of the stigma. Gaertner[10] reports that with certain plants he was able to obtain sterile fruits as large as normal ones by applying to the stigmas the spores of *Lycopodium*. Tschermak[32] reports various cases in the enlargement of the ovary by the use of pollen which did not fertilize the seed. Massart[19] secured partial development of fruits in certain Cucurbitaceous forms by applying triturated pollen to the stigmas. In these cases no seeds were fertilized and it appears that the pollen is the seat of an excitant which penetrates the stigma and determines the survival of the ovary. Furthermore Leclerc du Sablon[28] has found that the crossing of melons and cucumbers results in a considerable modification of the quantity and quality of the carbohydrates in the placenta and the pericarp.

The *Cucurbitaceae* have long been under the observation of botanists, and certain features in the development of their fruit have frequently attracted attention. Soon after Amici's discovery of the pollen-tube of *Portulaca oleracea*[1] (1823), Brongniart[5] (1826) described a cellular conducting tissue in *Cucurbita maxima* Duch. and showed the pollen-tube traversing the beak of the nucellus. He observed that the "spermatic granules" were transported by a canal formed of the intercellular spaces of the tissues of the pistil.

Gaertner,[9] in 1827, made observations on a number of plants and reported an acid secretion from the stigma in certain cases at the time of maturity, and also a correlation between the amount of pollen on the stigma and the number of seeds produced, and that the number of seeds was increased by cross-fertilization.

Amici,[2] in 1830, in a letter to Mirbel states that the pollen-tube gradually elongates, descending through the style, and comes into contact with the ovule, each ovule being reached by a separate tube.

Schleiden[29] (1844) traced the pollen-tube through the micropyle and point of the nucellus, even to the embryo-sac, in *Pepo, Melo, Cucumis, Lagenaria* and *Momordica*, and in the case of *Momordica* saw the germinal nuclei emerge from the pollen-tube.

Recently Guéguen,[11] in his studies on the comparative anatomy of the conducting-tissues of style and stigma, examined, among the *Cucurbitaceae*, *Ecballium Elaterium*, *Cucurbita Pepo* and *Bryonia*. He found the stylar canal present in *Ecballium*, but obliterated in *Cucurbita*, but states that where the stigma is tetramerous the conducting-tissue presents an X-like structure as seen in transverse section of the style. This conducting-tissue he observed extended to the ovules, covering the surface of the placenta. He regards the *Cucurbitaceae* as very uniform in the matter of conducting-tissue.

In 1902 Longo[18] announced that the nutrition of the embryo in *Cucurbita* was performed by means of the pollen-tube. At the base of the neck of the nucellus the pollen-tube expands into a large bulla provided with branches which traverse the nucellus and the inner integument and proceed in intimate relation with the internal layers differentiated from the outer integument. Owing to a cutinization in the walls of the epidermal cells of the nucellus, as well as a suberization in the region of the chalaza, the embryo is soon cut off from the usual source of nutritive materials. The pollen-tube, with its branches rich in plasmatic contents and in starch, and with cellulose walls, furnishes the only points where fluids can enter the nucellus. Thus a haustorial function is ascribed to the pollen-tube, which draws upon the inner layers of the outer integument, itself nourished by the vascular bundles.

In the following year Longo[17] published the results of a more extended investigation, including thirteen genera and several more species. In all the cases examined the branching of the pollen-tube was found as a rule only in *Cucurbita*, though in all cases the course of the pollen-tube was always in accord with the distribution of conducting-tissue. The formation of the bulla at the base of the neck of the nucellus is correlated with the presence of starch in the same neck. He found no expansion of the pollen-tube when the nucellus contained no starch; it forms simply a bulla without much branching (*Luffa maxima* Hort.) when the starch is normal, in very small grains; it forms a bulla with numerous branches (*Cucurbita*) when the starch is abundant in large grains, often in the form of amylo-dextrine. He concludes further that the course of the pollen-tube is regulated by particular substances which act in a chemotactic fashion; in this conclusion, agreeing with Lloyd.[16] When these substances are developed in the interior of the tissues it (the tube) has an endotropic course; when on the exterior an ectotropic course.

In an earlier article the writer made reference to the behavior of the pollen-tube in some of the *Cucurbitaceae*, and the phenomena observed in certain cases seemed worthy of further investigation. In most cases studied the pollen-tube presented no unusual conditions, but in a few instances the dilation or branching of the tube in the neck of the nucellus was a conspicuous feature. In *Cucurbita Pepo* the facts recorded by Longo were observed, and in other genera was noted a tendency similar, though less marked. The present study deals particularly with three members of the *Cucurbitaceae*, viz.: *Melothria pendula* L., *Micrampelis lobata* (Michx.) Greene, and *Cyclanthera explodens* Naud.

With a view to determining the length of time required for the pollen-tube to traverse the intervening tissue between the stigma and the embryo-sac, recourse was had to the following methods: Buds of the pistillate flowers about to open were covered with small bags of tissue paper tied about the peduncle. This was done usually between 4 and 6 o'clock P.M., and the flowers were usually found open the next morning. The stigmas were then pollinated and the bag replaced. At different intervals of time after pollination the fruits were collected and fixed in separate lots for study. Some were also examined fresh by means of freehand sections. In such preparations the pollen-tubes were easily recognized.

The effects of pollination were apparent soonest in the case of *Melothria*, in which the corolla-lobes close in over the stigma in a few hours. If pollination is not effected the flowers remain open for several days. In *Micrampelis* and *Cyclanthera* the results were not immediately apparent, only those parts of the stigma upon which the pollen germinated showing any change. Under normal conditions the pistillate flowers of *Melothria* are pollinated early in the morning from staminate flowers which open the same day. The staminate flowers are very ephemeral and fall off usually in a few hours.

The effects of pollination and fertilization in the *Cucurbitaceae* have been carefully studied by Massart,[19] who experimented with *Cucurbita*, *Bryonia*, *Ecballium* and *Thladiantha*. He finds that the excitation which determines the survival and the beginning of the increase in the size of the fruit of *Cucurbita Pepo* is derived from the pollen itself and may be replaced by a traumatism; but that the excitation which provokes the general increase in the fruit proceeds only from fertilized ovules. The placentae, however, do not develop except in the vicinity of the fertilized ovules.

As to the time required for the pollen-tube to reach the embryo-sac, considerable variation was observed, the time varying twenty hours or more, depending on the number and position of the ovules. After twenty-six hours the pollen-tube was observed in the nucellus of *Melothria* and the same condition appeared in *Micrampelis* after nineteen hours from the time of pollination. In *Cyclanthera* no tubes were observed at the ovules until forty-one hours had elapsed. Most of the distance between the stigma and the embryo-sac is traversed by the pollen-tube in three or four hours. During this time the tube has passed through the style and into the ovary. The growth is much slower as the tube nears the micropyle. This feature seems to be correlated with the amount of available reserve food in the tube, which is of course greatest at the beginning of its growth.

In the *Cucurbitaceae* the form and structure of the ovary in different genera varies a good deal, but in most cases the cavity of the ovary is practically filled by the fleshy development of the placentae and the pericarp. A fusion of the ingrowing lobes of the placenta often occurs (*Cucurbita*, *Citrullus*) and leaves no space between them. In a similar way the stylar canal may also be obliterated. In *Melothria*, *Micrampelis* and *Cyclanthera*, however, such fusion does not take place before fertilization. The structure of the ovary in *Melothria* is similar to that of *Cucurbita*, except that the ovules are arranged in one series instead of several on each flank of the three longitudinally-running placental lobes. Each of the placental lobes is covered with a single layer of cells, abounding in starch and possessed of denser plasmatic contents than those underneath. This layer also lines the narrow stylar canal, and covers the funicles of the ovules.

In *Micrampelis* the structure of the ovary is more complex. Here the normal ovary contains four ovules with their micropyles directed toward the pedicel. These are borne one on each flank of the two inwardly-growing placental lobes. In this case, however, the placental ridges become partially fused and grow downward toward the base of the ovary. In this genus as in *Melothria*, the cells which line the stylar canal and cover the placental lobes are filled with starch and denser protoplasm. Starch is also found in the underlying cells to a greater degree than in *Melothria*, but it is most abundant near the stylar canal and ovarian cavity.

Cyclanthera presents a condition in which there is one placental ridge in the ovary with a row of ovules on each flank. Here too the covering of the placenta and the lining of the stylar canal is similar to that of *Melothria* and *Micrampelis*. Both the epidermal covering of the placenta and that of the ovary-wall lying opposite (FIG. 14) are alike filled with starch, but those on the placenta are larger and more columnar in character. Here to a greater degree than occurs in the other cases the tissue beneath the epidermis is supplied with starch. Quite different from this is the condition found in *Cucurbita Pepo*, in which the conducting-tissue is devoid of starch. In *Cucurbita* the conducting-tissue consists of several layers of cells formed by the periclinal division of the epidermal cells covering the placentae.

The course of the pollen-tube in all cases under consideration is along the conducting-tissue just described. In *Melothria*, *Micrampelis* and *Cyclanthera* the tubes proceed down through the stylar canal and over the surface of the placentae. The tubes proceed upon the surface of the lobes wherever possible and not through them as a rule. In the restricted space of the style, where the canal offers insufficient space to accommodate many tubes, they traverse the surrounding tissues and break them down to a considerable extent. In such conditions, and elsewhere, where the course of the tube lies through the tissues, it appears to travel through the intercellular spaces. The destruction of cells in its path seems to be due mostly to mechanical action and not to digestive enzymes, except in the nucellus of *Cyclanthera*. Fresh ovaries when teased apart showed the pollen-tubes in the stylar canal and passing over various parts of the placental surface. FIGURES 1 and 3–5 represent the course of the tube.

When the surfaces of the placentae are pressed together or against the ovary-wall, the space through which the tubes move is considerably restricted. Under such circumstances they crowd aside the cells of the conducting tissue (FIG. 11). Sometimes a tube may be seen to have passed under the conducting layer (FIG. 15). Where the tubes traverse the ovarian space in *Melothria* they sometimes develop transverse walls or plugs. The manner of their development appears to be the formation of a ring transversely which gradually narrows the aperture until it is completely closed. An excessive development in thickness of this wall sometimes follows, forming plugs as shown in FIGURE 2 *a*, *b*, *c*. Similar plugs have already been observed by Osterwalder[26] in *Aconitum Napellus*, and by others.

The pollen-tube proceeds by an approximately direct course to the micropyle, and passes down through the nucellus to the embryo-sac. In the apex of the nucellus it usually expands to several times its normal diameter in *Cyclanthera* (FIGS. 6, 13), and from this point sends down a straight and narrow tube to the embryo-sac. Sometimes the entire neck of the nucellus is destroyed by the dilation of the tube. This expansion of the pollen-tube in the apex of the nucellus occurs frequently in *Melothria*, though it was never observed to reach the same proportions as in *Cyclanthera*. In *Micrampelis* also such conditions were sometimes observed; here, however, they are not the rule but the exception. In such cases, both in *Melothria* and *Cyclanthera*, the contiguous cells were destroyed.

That such dilations of the pollen-tube are directly correlated with the occurrence of starch in the surrounding tissues is maintained by Longo, as above pointed out; but the behavior of the pollen-tube of *Elodea*, as described by Wylie,[33] indicates that such conditions are not always the cause of the enlargments of the tube, for in this case they occur in the ovarian cavity. This has already been suggested by Lloyd[16] in discussing the pollen-tube in the *Cucurbitaceae* and *Rubiaceae*.

In the plants here under consideration the nucellus is practically devoid of starch, which is abundant in the integuments of *Micrampelis* and *Cyclanthera*, though not so abundant in *Melothria*.

The anatomical character of the conducting-tissue is a feature of some interest. In all cases examined a continuous conducting-tissue reaches from the stigma to the micropyle. In *Micrampelis* the neck of the nucellus pushes through the micropyle, and comes out even with the top of the integuments. Practically the same conditions exist in *Cyclanthera*, but in *Melothria* the apex of the nucellus is usually overtopped by the integuments. In the three genera just mentioned the conducting-tissue consists of a single layer of cells, the epidermis covering the placentae and lining the stylar canal. This layer appears to be the only one serving directly as conducting-tissue. On the stigma the starch is restricted to the subepidermal tissue, none appearing in the more densely plasmatic cells of the epidermis. The glandular character of the epidermal cells is quite apparent both on the stigma and in the interior (FIGS. 9, 11, 14). In the interior the cells in the path of the pollen-tubes show indications of activity, by the dense aggregation of the cytoplasm next the exposed side and surrounding large and conspicuous nuclei.

Considerable effort has been made to determine the directive force controlling the movements of the pollen-tube. We may note in passing that Nawaschin,[24] Zinger[34] and some others have interpreted the endotropic and ectotropic behavior of pollen-tubes as of phylogenetic significance. But evidence at present available seems to point to physiological processes and mechanical relations as the determining factors. In favor of this view we may cite the anatomical evidence contributed by Lloyd[15] in the *Rubiaceae*, Longo[17] on the *Cucurbitaceae*, and the observations of Capus[6] and of Guéguen,[11] and the results of the experimental studies of Miyoshi[20], [21] and others. Molisch[22] has shown that pollen-tubes are positively chemotropic and some negatively aerotropic. Miyoshi sowed pollen-grains on agar in which were imbedded pieces of stigma, ovary, and ovules of different degrees of development. Tne pollen-tubes grew toward the pieces from the vicinity of the stigma and were most strongly attracted by ovules ready for fertilization, growing into the micropyle in each case. He concludes that this stimulant is in the nature of a fluid, and in another article has shown that pollen-tubes grow into the stomata of *Tradescantia* leaves, the intercellular spaces of which have been filled with sugar solution. That the pollen-tube is also directed mechanically in its course is maintained by Miyoshi, and Capus states that the mechanical rôle of the conducting-tissue consists in placing the pollen-tube in relation with the micropyle, and that its economy and simplicity depend on the structure of the ovary.

That the stimulants which direct the pollen-tube are nutritive in character is quite evident. Dalmer[8] states that pollen-tubes are nourished by amyloid substances secreted by stigma, stylar canal, and the interior of the ovary, though he maintains that the entrance of the pollen-tube into the ovule is a purely mechanical phenomenon. Miyoshi points out that sugar as a stimulant can operate only extra-cellularly, and it is plain that where the course of the pollen-tube is intercellular or through the locular space of the ovary that its growth must be at the expense either of the reserve materials within the tube or of substances elaborated by the tissues in its path. The cytological features of the conducting-tissues of the *Cucurbitaceae* here under consideration are similar to those of certain nectaries in the abundance of starch and quantity of cytoplasm, appearance of molecular structures, etc. The evidence here points to the secretion of carbohydrates (probably sugar) as the nutritive material. That the pollen-tubes are partial to the more glandular cells is indicated in *Cyclanthera*. In this case the ovary sometimes shows a considerable locular space at the time of the entrance of the pollen-tubes. The epidermal cells of the placenta are larger and more glandular in appearance than those of the ovary-wall opposite. Though their distance apart is not great, the pollen-tubes always cling to the placenta instead of to the opposite wall, though that likewise is supplied with starch.

One noticeable feature of the relation between pollen-tube and conducting-tissue in *Melothria*, *Micrampelis* and *Cyclanthera* is the fact that while starch is abundant in the conducting-tissue, none appears in the tube. In *Cucurbita Pepo* on the other hand the conditions are reversed, and starch is entirely absent from the ample conducting-tissue, though abundant in the pollen-tube almost to the time of its entrance into the embryo-sac. These facts are regarded as evidence that the directive stimulant, in these cases at least, is of a different character from the substances in the tube. It is, however, recognized that the absence of starch from the cells of the conducting-tissue may not mean an absence of soluble carbohydrates, for no starch is visible in the secreting cells of some nectaries. The application of iodine to sections of the style and ovary of *Cucurbita* easily brings out the pollen-tubes in contrast with the conducting-tissue, the former rich in starch, coloring a dark blue, the latter a deep yellow, indicating an abundance of albuminous material. The pollen-tube branches in the nucellus according to the disposition of starch, as above cited in reference to Longo's work.

If the growth of the pollen-tube or its branches is thus regulated by the occurrence or distribution of nutritive material, we have apparently an explanation for the growth of the tube through the nucellus to the embryo-sac, structures which, in the cases here considered, are normally filled with starch before the approach of the pollen-tube.

At what distance from the ovule the pollen-tube comes under its influence, has not in these cases been determined, but it is evident that the embryo-sac is the source of a stimulant of some sort by which the pollen-tube is directed unerringly toward it. As to the character of this stimulant the evidence is meager, but what there is seems to indicate a sugar.

Miyoshi's results with the pollen of *Digitalis* and numerous other plants show that their tubes are sensitive to the presence of certain soluble carbohydrates, but are indifferent to or repelled by a variety of other substances. Moreover, the fact cited elsewhere by the same author to the effect that the pollen-tubes of distantly related plants were attracted to the same ovule and to different ovules would indicate that the stimulant is some substance quite common in plant tissues.

It is suggested here that a difference in the degree of concentration of such a solution as a sugar may be a sufficient factor in directing the pollen-tube. This is in accord with the observations of Miyoshi and others.

As to the particular organ of the embryo-sac responsible for the discharge of the stimulant, opinions have differed, some ascribing that function to the synergids and others to the egg-cell (Strasburger[31], Lloyd[15]). But to the writer it seems more probable that the source of such a stimulant may be found in the endosperm-nucleus and its cytoplasm. The appearance of this nucleus, indicating the large degree of activity, and its abundant cytoplasm filled with starch would favor such a view. The pollen-tube is presumably ruptured upon entering the embryo-sac by the rapid absorption of water and consequent increased turgor, and its contents discharged into the male generative nuclei come under the influence of the egg-cell and fertilization takes place, and in some cases also the fusion with the endosperm-nucleus.

SUMMARY AND CONCLUSIONS

1. The behavior of the pollen-tube was studied in *Melothria pendula*, *Micrampelis lobata*, and *Cyclanthera explodens*. As observed in these cases the time elapsing between pollination and the arrival of the pollen-tube at the embryo-sac was twenty-six hours in *Melothria*, nineteen hours in *Micrampelis*, and in *Cyclanthera* forty-one.

2. The pollen-tube follows conducting-tissue which for the most part is formed of the epidermis lining the stylar canal and covering the placental lobes. The tube traverses this tissue by passing over its surface wherever possible, and rarely affects the cells injuriously. The conducting-tissue of these plants is abundantly supplied with starch. In *Cucurbita Pepo* starch is wanting in the conducting-tissue but present in abundance in the pollen-tube. In all cases observed where starch abounded in the conducting-tissue it was absent from the pollen-tube. The pollen-tube appears to be directed by nutritive substances secreted by the conducting-tissue. Attention is called to the similarity in anatomical features of the cells of the conducting-tissue to those of certain nectaries, as evidence as to the nature of the secretion.

3. It is thought that the pollen-tube comes under the influence of a stronger stimulant emanating from the ovule. It is suggested that the source of this stimulus may be the endosperm-nucleus.

4. The evidence at hand supports the contention of Miyoshi and others that the behavior of the pollen-tube is a phenomenon

of chemotropism as against its being due to mechanical conditions or of phylogenetic significance.

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Description of plates 16 and 17

PLATE 16

1. Diagrammatic figure representing longitudinal section through gynoecium of *Melothria*. Course of pollen-tube (*P. t.*) intercellular.

2. *a*, *b*, *c*. Pollen-tube showing plugs.

3. Longitudinal section through gynoecium of *Micrampelis*. Conducting-tissue shaded.

4. Ovary of same at right angles to figure 3.

5. Longitudinal section through ovary of *Cyclanthera*, showing path of pollen-tubes.

6. Diagram of micropylar region of ovule of *Cyclanthera*, showing dilation of pollen-tube, *P. t.*

7. Ditto, *Melothria*.

8. Ditto, *Micrampelis*.

PLATE 17

9. Conducting-tissue of *Melothria* on placental folds. Pollen-tube in transverse section. × 440.

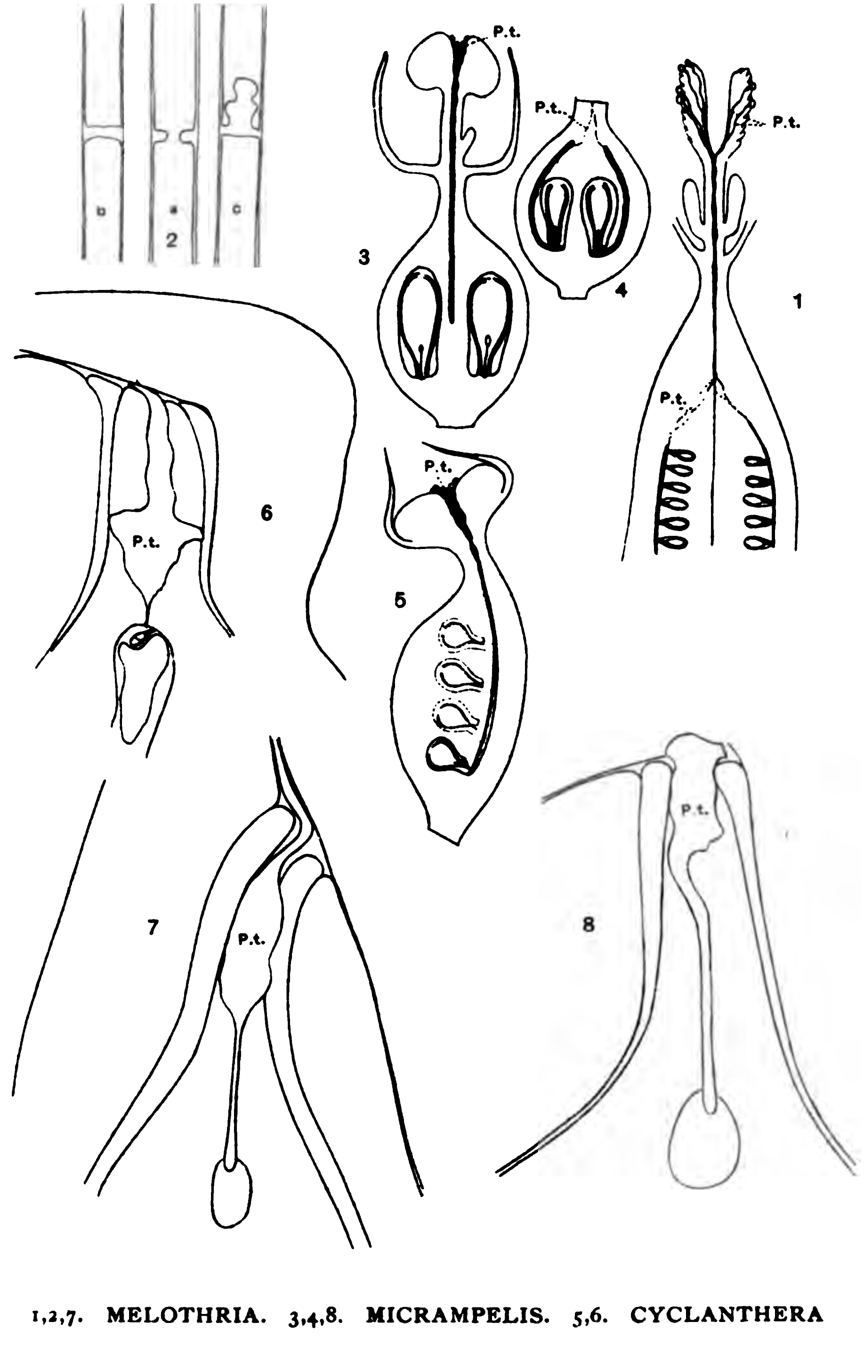
10. Conducting-tissue on funicle of ovule of *Melothria*. × 440.

11. Conducting-tissue of *Micrampelis*. Transverse section of pollen-tube. × 440.

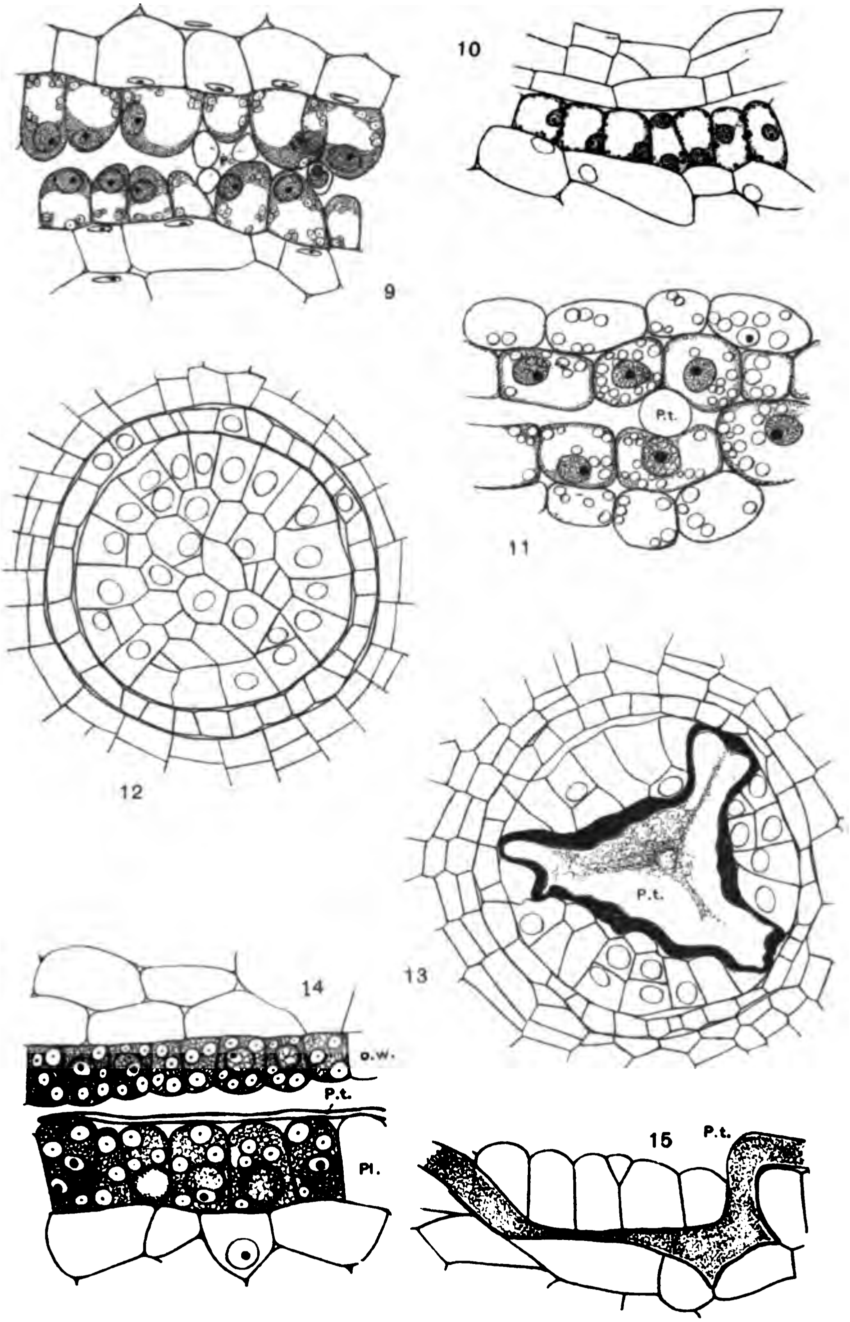
12, 13. Transverse section through neck of nucellus, in *Cyclanthera*, before and after passage of pollen-tube, *P. t.* × 440.

14. Conducting-tissue in ovary of *Cyclanthera*. *Pl.*, placenta ; *o. w.*, ovary-wall ; *P. t.*, part of pollen-tube. × 440.

15. Same showing pollen-tube (*P. t.*) passing under some cells of conducting-tissue. × 440.



1,2,7. MELOTHRIA. 3,4,8. MICRAMPELIS. 5,6. CYCLANTHERA



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PTERIDOPHYTA AND SPERMATOPHYTA

By ARTHUR HOLLICK

NEW YORK
1906

[From the MARYLAND GEOLOGICAL SURVEY: PLIOCENE AND PLEISTOCENE, pages 217-237, 278-281, *pl. 67-75.* 1906]

PTERIDOPHYTA.

Order FILICALES.

Family OSMUNDACEAE.

Genus OSMUNDA Linné.

OSMUNDA sp. ?

Plate LXVII, Fig. 3.

Description.—This specimen is one of the many masses of rootlets, attached to rhizomes, which occur in abundance in a black clay at the base of the bluff at Tally Point. Dr. L M. Underwood, of Columbia University, to whom they were submitted, decided unhesitatingly that they were the rootlets and rhizomes of some fern, most probably an *Osmunda*. It was found impossible to separate them from the matrix without breaking, either when wet or dry, hence they are shown in the figure exactly as collected and subsequently preserved.

Occurrence.—TALBOT FORMATION. Tolly Point (Bay Ridge) Anne Arundel County.

Collections.—Maryland Geological Survey.

SPERMATOPHYTA.

CLASS GYMNOSPERMAE.

Order CONIFERALES.

Family PINACEAE.

Genus PINUS Linné.

PINUS ECHINATA Mill.

Plate LXVII, Fig. 1.

Pinus echinata **Mill, 1768, Gard. Dict. ed. 8, No. 12.**

Description.—Cones of this species occur in abundance in the swamp debris at Bodkin Point. They are generally more or less flattened and are in the condition of brown lignite. The prickles do not seem to have been preserved in any instance.

Occurrence.—TALBOT FORMATION. Bodkin Point, Anne Arundel County.

Collections.—Maryland Geological Survey.

PINUS STROBUS Linné.

Plate LXVII, Fig. 2.

Pinus strobus Linné, 1753, Sp. Pl., p. 1001.

Description.—Only a single specimen of this species was found, which is the one here figured. Its condition is similar to that of the preceding species, with which it was found.

Occurrence.—TALBOT FORMATION. Bodkin Point, Anne Arundel County.

Collections.—Maryland Geological Survey.

PINUS sp. ?

Description.—Numerous seeds, detached cone scales, and fragments of bark occur at Bodkin Point and Grace Point, in regard to which generic determination only can be made.

Occurrence.—TALBOT FORMATION.

Collections.—Maryland Geological Survey.

Genus TAXODIUM Rich.

TAXODIUM DISTICHUM (L.) L. C. Rich.

Plate LXVIII, Figs. 1, 2.

Taxodium distichum L. C. Rich., 1810, Ann. Mus., Paris, vol. xvi, p. 298.

Description.—Amongst the most abundant remains in the debris of the buried swamp deposits are the branches, trunks, knees and cone scales of *Taxodium.* The presence of numerous stumps in place, with the knees attached, indicates that at these places there were typical cypress swamps, in which these trees made up a large part, if not the bulk of the vegetation.

Fig. 1 represents a knee, reduced to about one-fifth natural size, which was detached from one of the stumps standing exposed on the beach at Bodkin Point.

Fig. 2 represents a "burl" or excrescence, reduced to about one-half natural size, which was broken from one of the branches dug out of the mass of debris at the base of the bluff at the same place.

Occurrence.—TALBOT FORMATION. Bodkin Point, Grace Point, and Pond Neck.

Collections.—Maryland Geological Survey.

Genus SEQUOIA Endl.

SEQUOIA ANGUSTIFOLIA Lesq.

Plate LXXI, Figs. 16, 17.

Sequoia angustifolia **Lesq., 1872, Ann. Rept. U. S. Geol. and Geog. Surv. Terr., p. 372.**
Sequoia angustifolia **Lesq., 1878, Tert. Fl., p. 77, pl. vii, figs. 6-10.**
Sequoia angustifolia **Lesq., 1883, Cret. and Tert. Fl., p. 240, pl. 1, fig. 5.**

Description.—These specimens are referred provisionally to this species, for the reason that they also resemble very closely a number of figures which have been identified as the closely allied species *S. langsdorfi* (Brgt.) Heer, so that it is a matter of considerable difficulty to decide between them. Heer's figure of the latter (Fl. Tert. Helvet., vol. i, pl. xxi, fig. 4) is practically indistinguishable from the former and both are very similar to several forms of *Taxodium,* closely related to the living *T. distichum* (Linné) L. C. Rich, which, however, are still either more delicate or have leaves which are blunter than those from Maryland. A specimen apparently identical is figured by Knowlton (18th Ann. Rept. U. S. Geol. Survey, Pt. 3, pl. xcix, fig. 4) and referred provisionally to *S. angustifolia,* but he says (p. 723) "It is likely that in a revision of American fossil Sequoias this will have to be made a new species, unless it can be correlated with some known form."

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

CLASS ANGIOSPERMAE.

Subclass MONOCOTYLEDONAE.

MONOCOTYLEDON gen. et sp. ?

Plate LXX, Figs. 8-11.

Description.—These fragments are evidently portions of some monocotyledonous plant. Figs. 9 and 11 apparently represent the upper or outer part of the leaf blade, Figs. 10 and 12 the base. The nerves are fine, distinct, and separate below or at the middle of the leaf (Fig. 11) curving and running together above or near the margin (Fig. 9) Some at the basal portion of the leaf have the appearance of being forked (Figs. 10, 12), but this may be due to lateral compression. In dried herbarium specimens, parallel-veined leaves often present this appearance and the upper portion of Fig. 10 strongly suggests such a condition. Somewhat similar remains are figured by Heer, from the Miocene of Spitzbergen, under the name of *Alisma macrophyllum* (Fl. Foss. Arct., vol. iv, pt. i, p. 66, pl. xxvi, xxvii); from Eriz, Switzerland, as *Aronites dubius* (Fl. Tert. Helvet. vol. i, p. 98, pl. xlvi, fig. 5); and from the Baltic provinces as *Zingiberites undulatus* (Mioc. Balt. Fl., p. 64, pl. xvii, figs. 1-3). Comparison may also be made with *Musophyllum complicatum* Lesq. (Tert. Fl., p. 96, pl. xv) but the Maryland specimens are too fragmentary for even generic determination.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Subclass DICOTYLEDONAE.

Order JUGLANDALES.

Family JUGLANDACEAE.

Genus JUGLANS Linné.

JUGLANS ACUMINATA Al. Br. ?

Plate LXXII, Fig. 15.

Juglans acuminata **Al. Br., 1845, Neues Jahrb., p. 170.**

Description.—This specimen is probably referable to the above species as may be seen by comparison with those figured by Heer (Fl. Tert.

Helvet., vol. iii, pl. cxxviii), but only provisional reference is advisable in connection with such a fragment. Knowlton has figured a leaf from Bridge Creek, Oregon, and referred it provisionally to this species (Bull. U. S. Geol. Survey, No. 204, pl. iii, fig. 5), but the reference is questionable and the comparison is not as satisfactory as in the case of the Maryland specimen.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus HICORIA Raf.

HICORIA PSEUDO-GLABRA n. sp.

Plate LXXII, Figs. 1, 16, 17.

Description.—Terminal leaflet broadly obovate in outline, wedge-shaped at the base, finely serrate except near the base, short petioled; midrib thick; secondaries numerous, irregularly disposed, diverging from the midrib at obtuse but varying angles, mostly forking or branching once or twice near their extremities, the branches extending to the serrations; tertiary nervation fine and close. Lateral leaflets lanceolate (?) in outline, rounded and inequilateral at the base, entire below, serrate (?) above; secondaries irregularly disposed, sub-parallel, curving upward near the margin, the upper ones branching near their extremities.

These specimens are so contorted or imperfect that accurate description or comparison is impossible. They have much the appearance of many leaflets of the living *H. glabra* (Mill) Britton, in which the serrations are often obscure or entirely wanting below. The terminal leaflet may also be compared to *Aesculus simulata* Knowlton (Bull. U. S. Geol. Survey, No. 204, p. 78, pl. xv, figs. 1, 2) which is apparently a *Hicoria* rather than an *Aesculus.* The thick midrib, short petiole, entire, wedge-shaped base, and the irregular angle of divergence of the secondaries together with their branching extremities, are characteristics which are common to the Maryland specimen and to those figured by Knowlton. It is possible that Fig. 4, Plate LXX, may belong to the same species.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

HICORIA sp. ?

Plate LXX, Fig. 4.

Description.—This fragment is too imperfect for anything more than generic determination. It is apparently the terminal leaflet of a Hickory.

Occurrence.—SUNDERLAND FORMATION. Point of Rocks, Calvert County.

Collections.—Maryland Geological Survey.

HICORIA sp. ?

Description.—A small hickory nut, destitute of the outer husk, and considerably flattened, was found at Drum Point, but it was too distorted and imperfectly preserved for accurate or satisfactory specific determination.

Occurrence.—TALBOT FORMATION. Drum Point, Calvert County.

Collections.—Maryland Geological Survey.

Genus PTEROCARYA Kunth.

PTEROCARYA DENTICULATA (Web.) Heer.

Plate LXXII, Figs. 6-10.

Pterocarya denticulata Heer, 1859, Fl. Tert. Helvet., vol. iii, p. 94, pl. cxxxi, figs. 5-7.

Juglans denticulata Web., 1852, Palæontogr., vol. ii, p. 211, pl. xxiii, fig. 10. (Not *J. denticulata* Heer, 1869, Fl. Foss. Arct., vol. ii, Abth. iv, p. 483, pl. lvi, figs. 6-9.)

Description.—These leaves are apparently identical with those figured by Ettingshausen under the above name (Foss. Fl. Bilin, pl. liii, figs. 11-15), although they might with propriety be referred to the genus *Hicoria*, as they are closely related to *H. pecan* (Marsh.) Britton, or to *H. minima* (Marsh.) Britton, many trees of which bear leaflets that are dentate above and entire below, as is the case in these specimens and in most of the figures with which they have been compared. Lesquereux described a somewhat similar leaf under the name *Pterocarya americana* (Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1873, p. 417; Tert. Fl., p. 290, pl. lviii, fig. 3) in relation to which he says: (p. 291) "as Pterocarya is an Asiatic genus. . . . it would be more advisable to consider the fragment as that of a leaflet of Carya [Hicoria] or of Juglans." Knowlton has also described a species under the name *Juglans cryptata* (Bull. U. S. Geol. Survey, No. 204, p. 35, pl. vi, figs. 4, 5) which differs but little from the latter, except in size. Under the circumstances it does not seem advisable to complicate the synonomy any further by introducing the generic name *Hicoria,* which may more properly be done elsewhere.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus POPULUS Linné.

POPULUS CLARKIANA n. sp.

Plate LXX, Fig. 6.

Description.—Leaf deltoid in shape, slightly rounded at the center, rather abruptly acuminate above, cuneate or sub-cordate below, crenulate-dentate except near the base and apex; petiole about 3/10 inch long; nervation 3-palmate; lateral primaries and principal secondaries spreading, sub-parallel, camptodrome; from the under sides of the lateral primaries and from the outer sides of the marginal loops of the secondaries a series of fine nerves and nervilles extend to the crenulations of the margin.

Named in honor of Professor W. B. Clark, under whose auspices the collection was made. There are no described or figured species with which this leaf may be satisfactorily compared, but it approaches very close to some of the forms of *P. deltoides* Marsh, especially var. *occidentalis* Rydb.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

POPULUS LATIOR Al. Br. ?

Plate LXX, Fig. 7.

Populus latior **Al. Br., 1837, in Buckland, Geology, vol. 1, p 512.**

Description.—Although fragmentary and imperfect this specimen shows characters sufficient to identify it, at least provisionally, with the above species and probably with the variety *rotundata* as figured by Heer (Fl. Tert. Helvet., vol. ii, pl. lvi, figs. 4-7). It may also be compared with *P. lindgreni* Knowlton (18th Ann. Rept. U. S. Geol. Survey, pt. 3, p. 725, pl. c, fig. 3; Bull. U. S. Geol. Survey, No. 204, p. 29, pl. ii, fig. 1) and it is evidently closely related to the living *P. deltoides* Marsh, all of which differ from each other less than the leaves of the latter, on a single tree, often differ between themselves.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

POPULUS PSEUDO-TREMULOIDES n. sp.

Plate LXX, Fig. 5.

Description.—Leaf orbicular or transversely elliptical in shape, tapering abruptly and about equally to the somewhat decurrent base and acuminate apex, about 1 1/10 inch in length and width; margin entire; petiole ½ inch in length; nervation 3-palmate, camptodrome; lateral primaries arising from very near the base of the leaf at an angle of about 45 degrees with the midrib and curving gently upward, each with three secondaries on the lower side curving toward the margin; median secondaries fine, about two on each side of the midrib, extending upward at acute angles and curving at their extremities. This leaf is hardly to be distinguished from many entire-margined forms of the living *P. tremuloides* Michx. and is similar to *P. decipiens* Lesq. (Tert. Fl., p. 179, pl. xxiii, figs. 7-11), although in this species the lateral primaries are more upright.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Order FAGALES.

Family BETULACEAE.

Genus CARPINUS Linné.

CARPINUS PSEUDO-CAROLINIANA n. sp.

Plate LXXI, Fig. 10.

Description.—Leaf about 1¼ inch long by ½ inch wide, oblong; abruptly acuminate at the apex, finely serrate; secondary nerves numerous, fine, sub-parallel, leaving the midrid at an acute angle and extending to the serrations of the margin. This leaf is almost identical with many smaller leaves of the living *C. caroliniana* Walt., which are frequently simply instead of doubly serrate. Numerous similar fossil forms have been described under *C. grandis* Ung. and *C. heerii* Etts., and Lesquereux has figured specimens under the former name from the western United States which approach the Maryland leaves very closely (Tert. Fl. pl. lxiv, figs. 8-10). They are described as doubly serrate, although the smaller specimens are figured as simply serrate, the same as the former. Practically the only difference between them is the abruptly acuminate apex of the latter, as compared with the more gradually tapering apex of the former.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus ALNUS Gaertn.

ALNUS RUGOSA (Du Roi) K. Koch.

Plate LXIX, Figs. 1-3.

Betula Alnus rugosa **Du Roi, 1771, Harbk. vol. 1, p. 112.**
Alnus rugosa **K. Koch, 1872, Dend., vol. ii, pt. 1, p. 635.**

Description.—Numerous leaf impressions of this species occur in the fine silt at Drum Point, but it was found almost impossible to preserve them long enough for depicting, as they dried and cracked on exposure to the air. The ones figured were drawn before the matrix had had time to dry.

Occurrence.—TALBOT FORMATION. Drum Point, Calvert County.

Collections.—Maryland Geological Survey.

Family FAGACEAE.

Genus FAGUS Linné.

FAGUS AMERICANA Sweet.

Fagus americana **Sweet, 1826, Hort. Brit., p. 370.**

Description.—Nuts and husks, sometimes separate from each other, sometimes entire, are amongst the most abundantly represented objects in the swamp deposits.

Occurrence.—TALBOT FORMATION. Bodkin Point, Anne Arundel County, Grace Point, Baltimore County, and Grove Point, Cecil County.

Collections.—Maryland Geological Survey.

FAGUS sp. ?

Plate LXX, Fig. 3.

Description.—This fragment apparently represents the leaf of a Beech, but there is not enough upon which to either make comparisons or base a description.

Occurrence.—SUNDERLAND FORMATION. Point of Rocks, Calvert County.

Collections.—Maryland Geological Survey.

Genus QUERCUS Linne.

QUERCUS GLENNII n. sp.

Plate LXXII, Figs. 3-5.

Description.—Leaves oblong-lanceolate (?) in outline, tapering to the apex, rounded or narrowed (?) to the base; margin somewhat irregular or wavy, minutely denticulate; secondaries springing from the midrib at varying angles, curving upward, sub-camptodrome, with fine nervilles extending to the denticulations. These leaves are named in honor of Dr. L. C. Glenn, in whose company they were collected. They are very closely allied to the living *Q. wislizenii* Engelm.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

QUERCUS PSEUDO-ALBA n. sp.

Plate LXX, Fig. 2; Plate LXXI, Figs. 1-6.

Description.—Leaves varying in size and outline, irregularly pinnatifid into obtusely pointed lobes, the lower ones entire and extended into a wedge-shaped base, the upper ones occasionally sub-lobed (?); sinuses rounded; secondary nervation irregular, consisting of a series of main nerves extending from the midrib at varying angles to the extremities of lobes, with forks extending to the extremities of the sub-lobes (?) and an intermediate finer series extending with the tertiary nerves and finally forming sub-marginal nerves extending along the margins of the lobes.

These leaves appear to be practically identical with many forms of the living *Q. alba* L. and they might also be compared with forms of *Q. macrocarpa* Michx. and *Q. lyrata* Walt., all of which vary greatly in size and shape. *Q. garryana* Dougl., *Q. utahensis* (A. D. C.) Rydb. and *Q. gunnisoni* (Torr.) Rydb. may also serve for comparison, but the imperfect condition of the Maryland specimens renders it impossible to determine accurately their nearest allies in the living flora, hence it has been thought best to merely indicate in the name adopted the general apparent relationship with the white oak group.

Occurrence.—SUNDERLAND FORMATION. Point of Rocks and near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus ULMUS Linné.

ULMUS BETULOIDES n. sp.

Plate LXX, Fig. 1.

Description.—Leaf oblong-ovate (?) in outline, serrate; secondary nerves leaving the midrib almost at right angles, mostly forking or branching once or twice near the extremities, each division terminating in one of the marginal serrations; base and apex not known. This leaf by reason of the obtuse angle of divergence made by the secondaries with the midrib, appears to be distinct from any species with which it was compared. In some respects it resembles a *Betula* rather than an *Ulmus,* but it apparently was inequilateral or cuneate at the base, as indicated by the more rounded outline on the left side and the slightly curved midrib. With an apex such as that shown in Fig. 11, Plate V, the leaf would approach very closely to many forms of *U. americana* L.

Occurrence.—SUNDERLAND FORMATION. Point of Rocks, Calvert County.

Collections.—Maryland Geological Survey.

ULMUS PSEUDO-RACEMOSA n. sp.

Plate LXXI, Figs. 11-13.

Description.—Leaves varying in size, averaging about 2 inches in length by 1 inch in width, oval to somewhat obovate in outline, inequilateral, sharply and more or less doubly serrate; apex rather abruptly acuminate; base cuneate or cuneate-cordate; petiole short; nervation simply pinnate, craspedodrome, the secondaries numerous, flexuous, varying in their angles of divergence from the midrib and mostly once to several times forked, especially towards their extremities, the branches of the forks terminating in the minor dentitions of the margin.

It is almost impossible to separate these leaves from those of the living *U. americana* L., and *U. racemosa* Thomas, and it is quite possible that they are identical with one or the other of these species. They may be more or less satisfactorily compared with several fossil forms, such as

U. affinis Lesq. (Mem. Mus. Comp. Zool. Harvard College, vol. vi, No. 2, p. 16, pl. iv, figs. 4, 5) which, however, is described as long petioled; *U. pseudo-americana* Lesq. (Cret. and Tert. Fl., p. 249, pl. liv. fig. 10) which differs principally in its larger size and in the strict, parallel character of its nervation; *U. tenuinervis* Lesq. (Ann. Rept. U. S. Geol. and Geog. Surv. Terr. 1873 [1874] p. 412; Tert. Fl., p. 188, pl. xxvi, figs. 1-3) which is more elongated; and also with *U. fisheri* Heer, *U. plurinervia* Ung. and *U. bronnii* Ung., all of which species differ from each other no more than the leaves of *U. racemosa* or *U. americana* on a single branch often differ between themselves. The apparent relationship is indicated in the specific name adopted, instead of referring the fossil, without question to the living species.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

ULMUS sp. ?

Plate LXIX, Fig. 10.

Description.—This fragment is too imperfect for more than generic determination, but apparently it belongs to the living *U. racemosa* Thomas.

Occurrence.—TALBOT FORMATION. Grove Point, Cecil County.

Collections.—Maryland Geological Survey.

Genus PLANERA J. F. Gmel.

PLANERA UNGERI Etts.

Plate LXXI, Figs. 14, 15.

Planera ungeri **Etts, 1851, Foss. Fl. Wein, p. 14, pl. ii, figs. 5-18.**

Description.—This species, as originally depicted by Ettingshausen, is represented by small leaves similar to those now figured, but other authorities have included a wide range of forms, varying greatly in size, shape, and character of the dentition. (See Heer, Fl. Tert. Helvet., vol. ii, pl. lxxx; Fl. Foss. Arct., vol. i, pl. ix, fig. 14b; ibid. vol. ii, Fl. Foss.

Alask, pl. v, fig. 2; ibid., vol. ii, Foss. Fl. N. Greenl. pl. xlv, figs. 5a, c and xlvi, figs. 6, 7a; ibid., vol. v, Foss. Fl. Sibiriens pl. xv, fig. 19; ibid., vol. v, Mioc. Fl. Sachalin, pl. ix, fig. 10 and x, figs. 1, 2; ibid., vol. vii, pls. lxxv, fig. 11, lxxxix, fig. 9, xcii, fig. 9, xcv, figs. 6, 7 and xcvii, fig. 3; Lesq. Tert. Fl., pl. xxvii, fig. 7, etc.) Figure 14 might also be compared with *Ulmus minuta* Gœpp. (Zeitsch. Deutsch. Geol. Gesellsch., vol. iv, p. 492; Tert. Fl. Schossnitz, p. 31, pl. xiv, figs. 12-14), but it would seem to be the wiser course not to separate this mere fragment from the other with which it is associated.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus CELTIS Linné.

CELTIS PSEUDO-CRASSIFOLIA n. sp.

Plate LXXI, Fig. 9.

Description.—Leaf about 1½ inch long by ¾ inch wide, inequilateral (?) sparingly dentate below, entire above and tapering irregularly to the apex; secondary nervation camptodrome, consisting of a pair springing from the base and three or more above, which bend abruptly near the midrib and extend upward almost parallel with it; tertiary nervation approximately at right angles between the secondaries and between the secondaries and the midrib, curving upward from the outside of the basal secondaries, where they connect close to the margin, with fine sub-divisions extending to the dentitions.

It is unfortunate that only this fragmentary specimen was obtained upon which to base a description. It is apparently closely related to several living species, such as *C. crassifolia* Lam., *C. mississippiensis* Bosc., *C. georgiana* Small, and *C. occidentalis* L., in all of which the leaves may vary considerably in size, shape, and degree of dentition and with any one of which it could be compared more satisfactorily than with any described fossil species. This apparent relationship is therefore indicated in the specific name adopted.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Order POLYGONALES.

Family POLYGONACEAE.

Genus POLYGONUM Linné.

POLYGONUM sp ?

Description.—Numerous seeds of this genus occur in the various swamp deposits, especially at Grace Point, but accurate specific identification is not possible.

Occurrence.—TALBOT FORMATION. Grove Point, Cecil County; Grace Point, Baltimore County.

Collections.—Maryland Geological Survey.

Order ROSALES.

Family PLATANACEAE.

Genus PLATANUS Linné.

PLATANUS ACEROIDES Gœpp.

Plates LXXIII, LXXIV.

Platanus aceroides Gœpp, 1855, Zeitschr. Deutsch. Geol. Gesellsch., vol. iv, p. 492; Tert. Fl. Schossnitz, p. 21, pl. ix, figs. 1-3.

Description.—This widely represented species is hardly to be distinguished from the living *P. occidentalis* L. and there would be no inconsistency in considering them as identical.

The fragments figured on Plate LXXIII may be compared with those figured by Heer from Spitzbergen, (Fl. Foss. Arct., vol. i, pl. xxxii, figs. 1, 2; ibid., vol. iv (Foss. Fl. Spitzb.), pl. xvii, figs. 1, 2 and xxxi, fig. 3), Greenland (Fl. Foss, Arct., vol. vii, pl. xc) and Switzerland (Fl. Tert. Helvet., vol. ii, pl. lxxxvii, figs. 3, 4 and lxxxviii, figs. 10, 11) and the smaller leaves on Plate LXXIV with similar ones on the plate last cited. Gaudin and Strozzi also figure a number of specimens from Italy (Mem.

Feuilles Foss. Toscane, vol. i, pl. v, figs. 4-6 and vi, figs. 1-3, etc.) and Lesquereux, from the United States (Tert. Fl., pl. xxv, figs. 4, 5; Cret. and Tert. Fl., pl. xlix, fig. 1). The latter author also described and figured what is apparently this species under the name *Acer æquidentatum* sp. nov. (Mem. Mus. Comp. Zool. Harvard College, vol. vi, No. 2, p. 26, pl. vii, figs 4, 5) which, however, is not the same species as that figured under the name in his Tertiary Flora, pl. xlviii, figs. 1, 3. Gœppert's figures l. c. and also his figures of *P. œynhausiana* (l. c. pl. x, figs. 1-4) apparently all represent one species, identical with that from Maryland. It may be questioned whether figures 2-5 on Plate LXXIV should be included with the others. They appear to represent leaves in which the margins were entire or very coarsely dentate, as in *P. mexicana* Moric., but there is not enough upon which to base a description. Figure 5, last quoted, apparently represents a portion of a basilar lobe, such as may often be seen in *P. occidentalis* and similar to the appendages of *P. basilobata* Ward (Synop. Fl. Laramie Gr. 6th Ann. Rept. U. S. Geol. Survey, pls. xlii, xliii). No such lobe or appendage is indicated in any of the figures of *P. aceroides* or its nearest allies, and this might perhaps constitute a distinctive feature which would be regarded as specific.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

PLATANUS sp. ?

Plate LXXV.

Description.—This is apparently a portion of a very large *Platanus* leaf. It was approximately 12 inches in width and 8 or 9 inches in length.

Occurrence.—SUNDERLAND FORMATION, Point of Rocks, Calvert County.

Collections.—Maryland Geological Survey.

Family DRUPACEAE.

Genus PRUNUS Linné.

PRUNUS ? MERRIAMI Knowlton.

Plate LXXII, Fig. 2.

Prunus ? merriami Knowlton, 1902, Bull. U. S. Geol. Survey, No. 204, p. 67, pl. xi, figs. 2, 3, 6, 7.

Description.—There can be no question as to the identity of the Maryland specimen with those figured by Knowlton, but the reference to the genus *Prunus* is more than questionable. It is most likely a *Hicoria.* In fact his *P. tufacea* (l. c. pl. xi, fig. 4) might well be united with it under one species, as representing the lower leaflets, and his *Rhus* (?) sp. (l. c. pl. xiv, fig. 6) as representing a terminal one. The identification of the specimens, however, is of more importance from the standpoint of stratigraphy than is the correct determination of their botanical affinities.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Genus CASSIA Linné.

CASSIA sp. ?

Plate LXXI, Fig. 20.

Description.—This single small leaflet is hardly sufficient upon which to base a description of a new species or for making satisfactory comparisons. It is apparently slightly inequilateral at the base and has some resemblance to *C. ambigua* Ung. (Gen. et Sp. Pl. Foss., p. 492; Syll. Pl. Foss., vol. ii, pl. x, fig. 9) and to *Leguminosites salicinus* Heer (Fl. Tert. Helvet. vol. iii, p. 128, pl. cxxxix, figs. 28-30), but as the nervation is not apparent it has been thought best not to refer it even provisionally to either of the above species.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County

Collections.—Maryland Geological Survey.

Family PAPILIONACEAE.

Genus ROBINIA Linné.

ROBINIA PSEUDACACIA Linné.

Plate LXIX, Fig. 4.

Robinia pseudacacia Linné, 1753, Sp. Pl. p. 722.

Description.—A single leaf of this species was found in the swamp deposit at Bodkin Point.

Occurrence.—TALBOT FORMATION. Bodkin Point, Anne Arundel County.

Collections.—Maryland Geological Survey.

Genus ACER Linné.

ACER sp. ?

Plate LXXI, Figs. 7, 8.

Description.—These two figures represent counterparts of the same fruit. No leaves of *Acer* were found associated with it, and hence it seems unwise to give a specific name, although it appears to be quite distinct from any other similar fruit which has been figured or described. The seed appears to be smaller than is usually the case, although this appearance may be due to the imperfection of the specimen.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Family SAPINDACEAE.

Genus SAPINDUS Linné.

SAPINDUS MARYLANDICUS n. sp.

Plate LXXII, Figs. 11-14.

Description.—Leaves inequilateral, curved, entire, very unequal below and tapering to the base at each side; greatest convexity on the broader side at about ⅓ the distance from the base and on the narrower side at about the same distance from the apex; secondary nervation irregularly disposed at varying angles of divergence from the midrib, curving and anastomosing near the margin or irregularly connected by oblique or curved tertiaries.

This species is somewhat suggestive of *S. oregonianus* Knowlton (Bull. U. S. Geol. Survey, No. 204, p. 79, pl. xv, fig. 3) and to *S. obtusifolius* Lesq., (Ann. Rept. U. S. Geol. and Geog. Surv. Terr., 1873, p. 419, Tert. Fl. pl. xlix, figs. 8-11; Cret. and Tert. Fl. pl. xlviii, figs. 5-7) but differs in the more tapering base. It is possible that all specimens might not exhibit this characteristic to the same extent, in which case the similarity with *S. oregonianus* would be very close.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

Order RHAMNALES.

Family VITACEAE.

Genus VITIS Linné.

VITIS sp. ?

Grape seeds are plentiful in the swamp deposits of Talbot age at Bodkin, Grace, and Grove Points, and are sparingly represented in the deposits at Drum Point.

Order UMBELLALES.

Family CORNACEAE.

Genus NYSSA Linne.

NYSSA BIFLORA Walt.

Plate LXIX, Fig. 5.

Nyssa biflora Walt., 1788, Fl. Car., p. 253.

Description.—Several leaves, apparently identical with the one figured, were found in the Talbot swamp deposits at Drum Point and Bodkin Point, but with one exception it was found to be impossible to preserve them long enough to permit of their being drawn. The specimen figured is from the former locality.

NYSSA sp. ?

Seeds of *Nyssa* are abundantly represented in the Talbot swamp deposits at Bodkin and Grace Points and a few were found in the deposit at Drum Point.

Order ERICALES.

Family ERICACEAE.

Genus XOLISMA Raf.

XOLISMA LIGUSTRINA (Linné) Britton.

Plate LXIX, Fig. 6.

Xolisma ligustrina Britton, 1894, Mem. Torrey Club., vol. iv, p. 135.

This leaf is the only one of several which were found in the Talbot swamp deposits at Bodkin Point which was sufficiently well preserved for figuring.

Family VACCINIACEAE.

Genus VACCINIUM Linné.

VACCINIUM CORYMBOSUM Linné.

Plate LXIX, Figs. 7-9.

Vaccinium corymbosum Linné, 1753, Sp. Pl., p. 350.

A number of impressions of these leaves were found in the fine silt of Talbot age at Drum Point, from which the specimens figured were selected.

Order EBENALES.

Family SAPOTACEAE.

Genus BUMELIA Linné.

BUMELIA PSEUDO-LANUGINOSA n. sp.

Plate LXXI, Figs. 18, 19.

Description.—Leaves spatulate or oblong-spatulate in shape, entire, narrowed to an acute or wedge-shaped base; apex not known; midrib well defined; secondary nervation obscure and fine.

These leaves bear a very close resemblance to several of those of living species of *Bumelia,* especially *B. lanuginosa* Pers. and *B. monticola* Buckl., from either of which could be selected specimens which would match them exactly in outline, but the absence of definite nervation renders accurate comparison impossible.

Occurrence.—SUNDERLAND FORMATION. Near the headwaters of Island Creek, Calvert County.

Collections.—Maryland Geological Survey.

UNDETERMINED.

In addition to the genera and species determined and described there remain about a dozen species of small seeds which could not be identified except as belonging in certain families or orders and hence have not been included. Among these were quantities of a peculiar moniliform object which at first were mistaken for seeds and then for small fungoid growths. Careful examination showed that they could not be referred to either of these and their close resemblance to galls suggested that they might be of insect origin, similar to such as are found on the leaves of the living Bald Cypress (*Taxodium distichum* (L.) L. C. Rich). Specimens were sent to Dr. L. O. Howard, of the Division of Entomology, U. S. Dept. Agriculture, who kindly examined them and from whose report the following is quoted: "The little swellings on the leaf of the Bald Cypress appear to be the work of one of the gall gnats, a Cecidomyiid. Those from the Pleistocene swamp deposits of Maryland appear to be the same. . . . The material was badly crushed when received. Still I do not know that any more accurate determination could be made of the material in its best condition."

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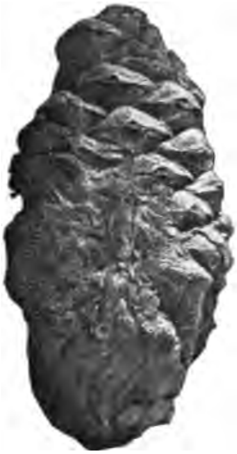

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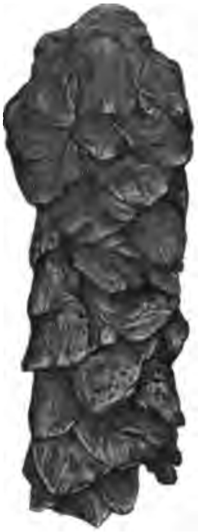

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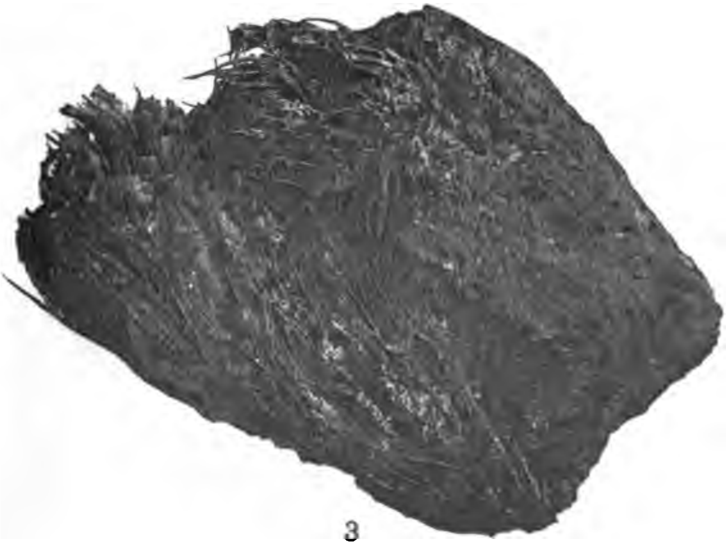

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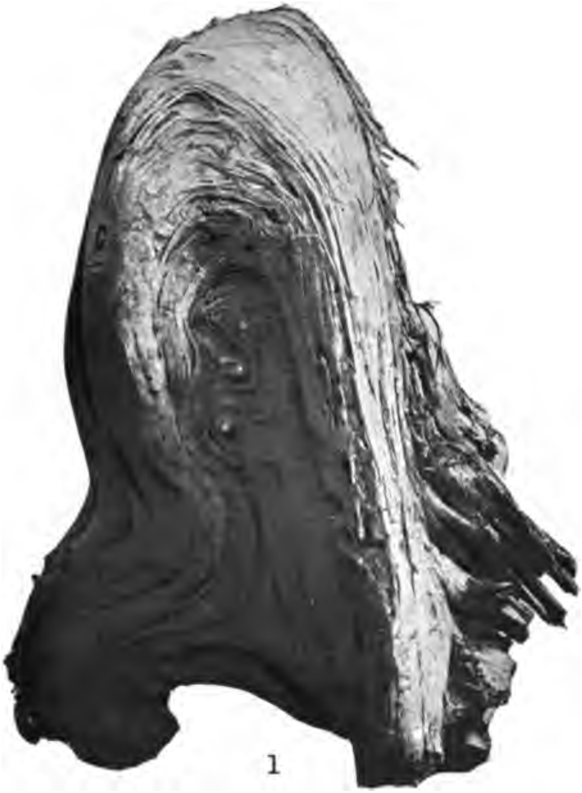

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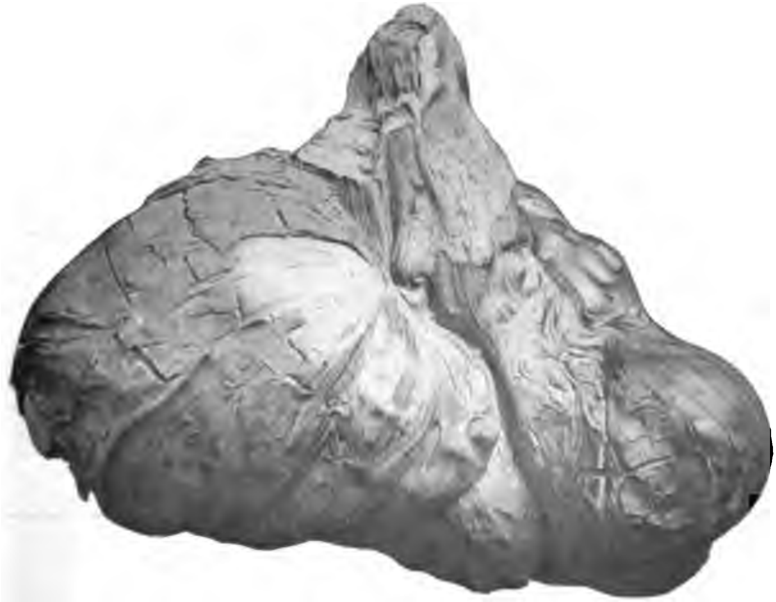

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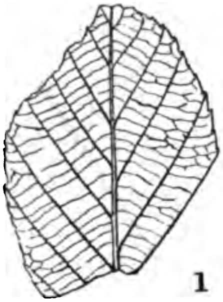
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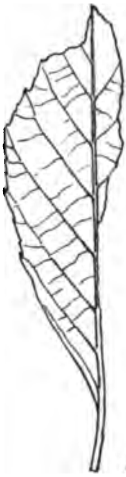
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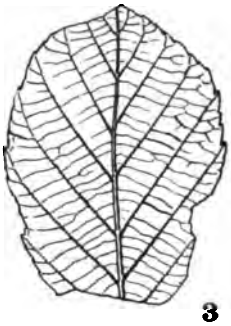
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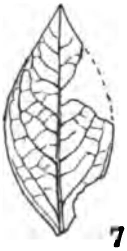
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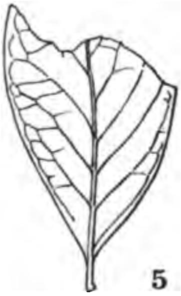
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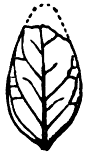
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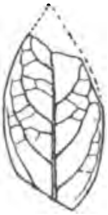
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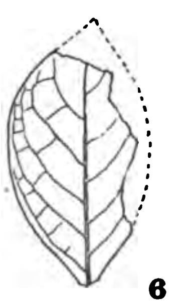
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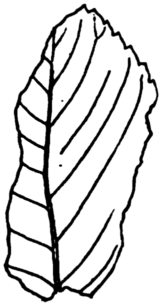
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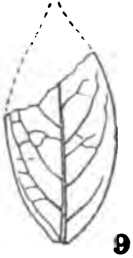
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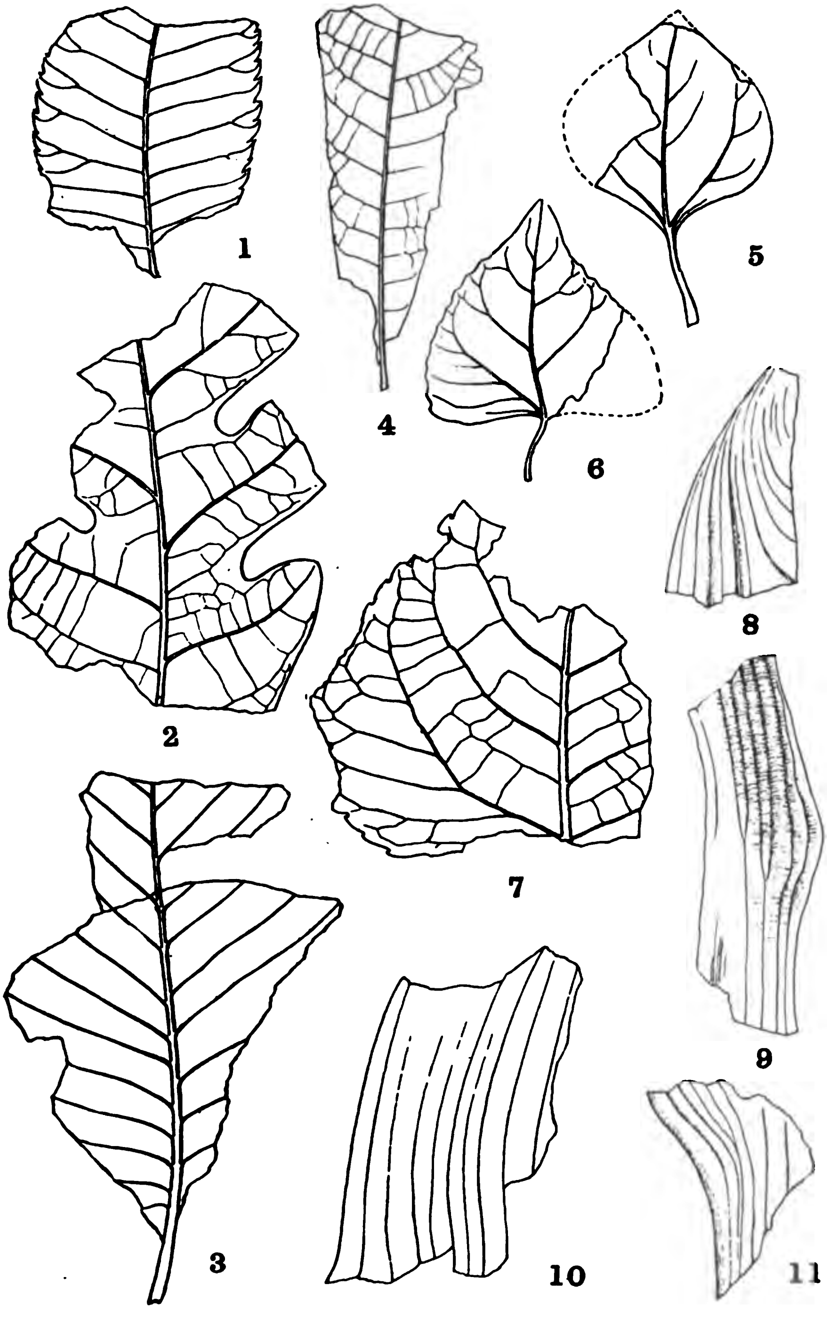

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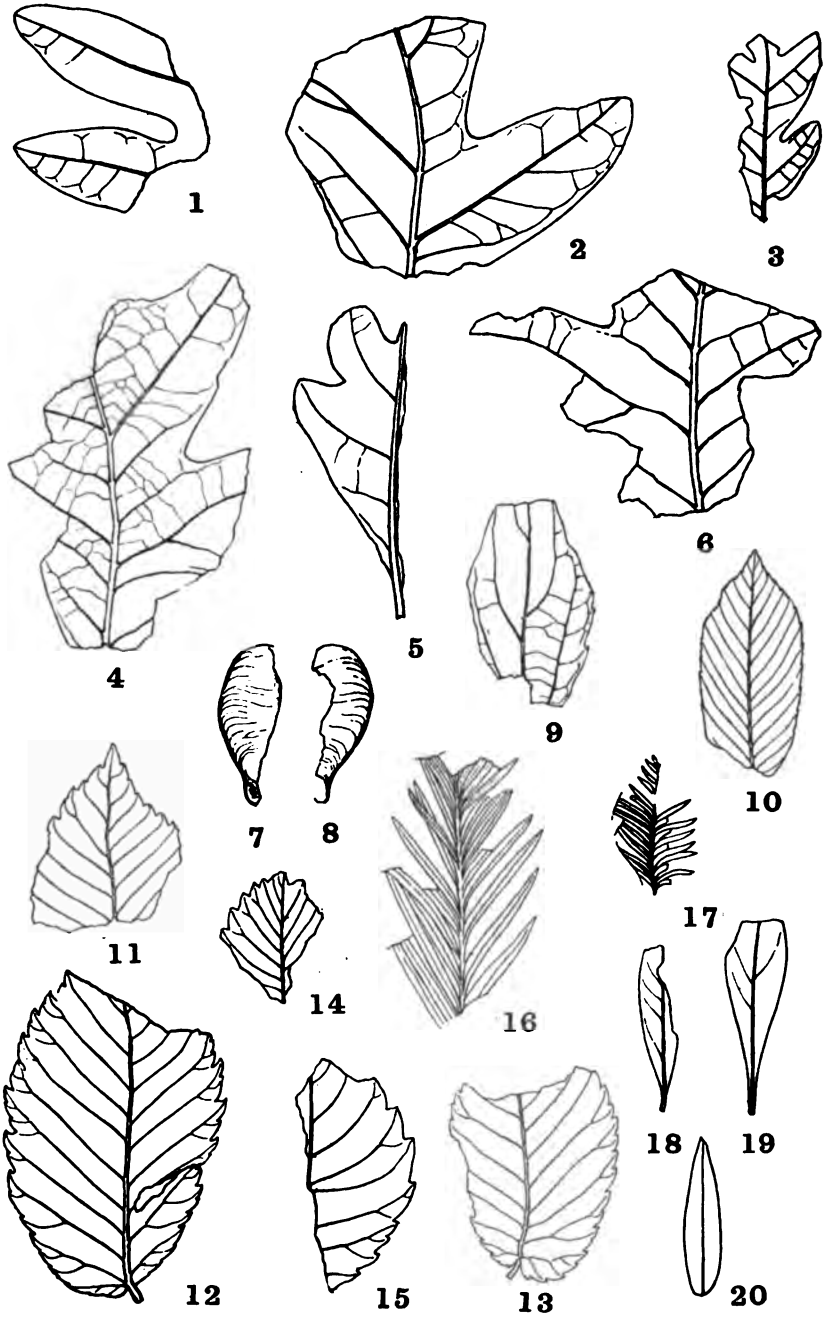

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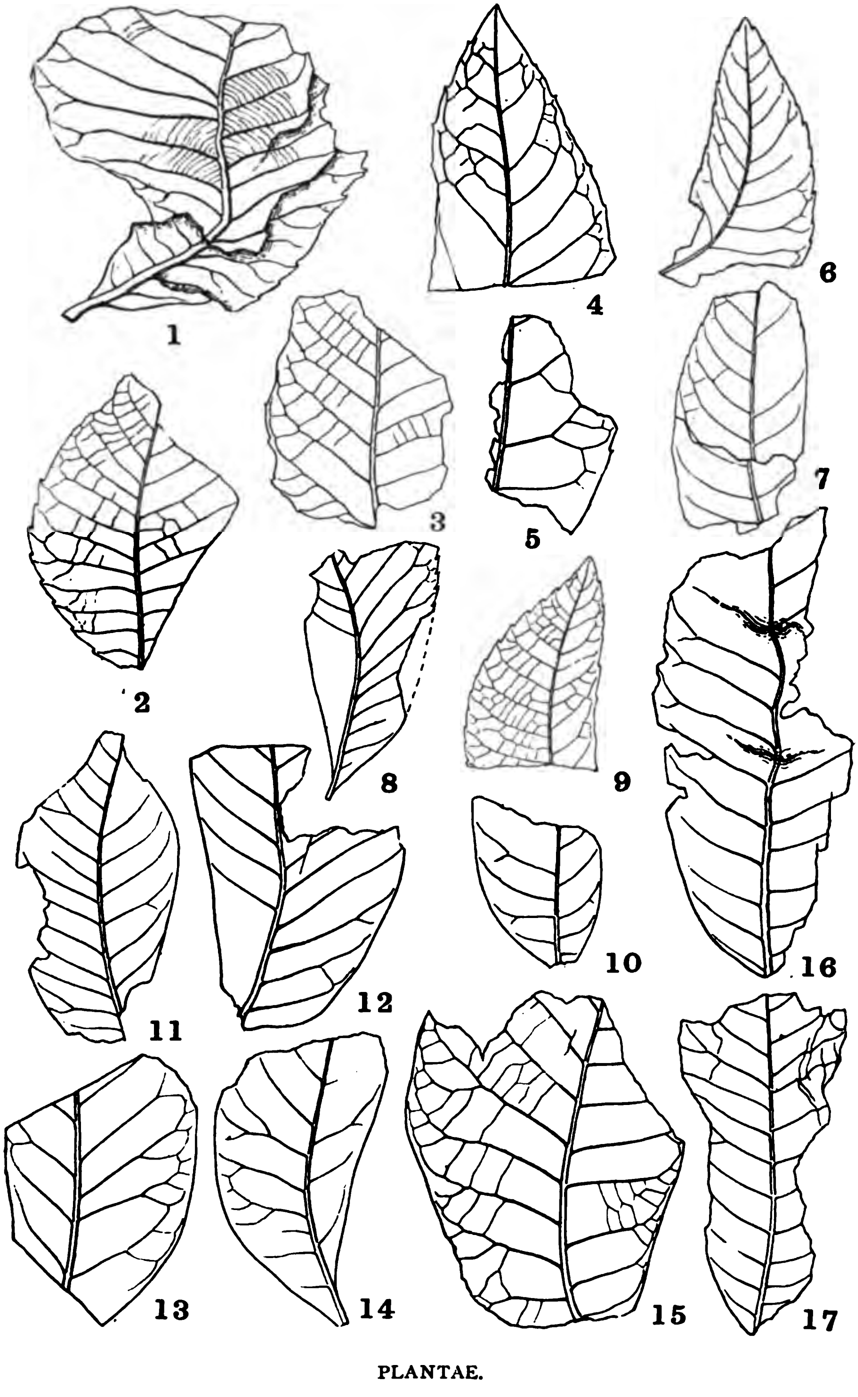

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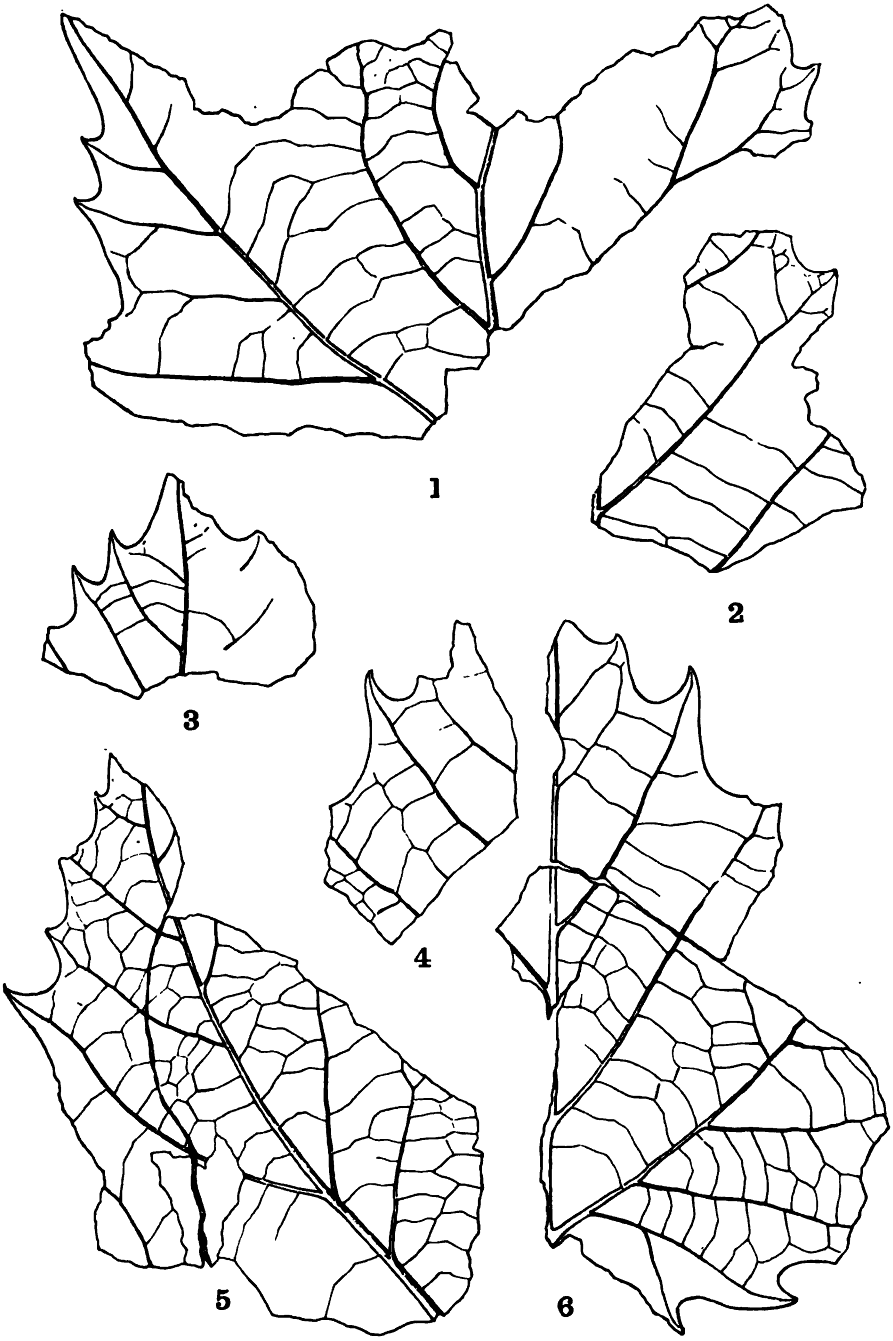

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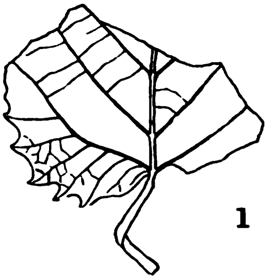

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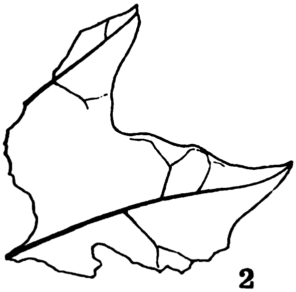

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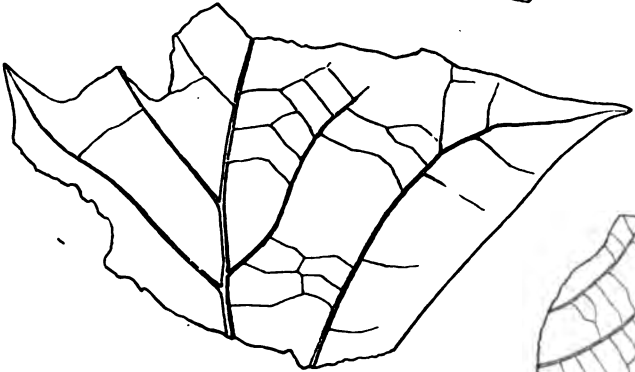

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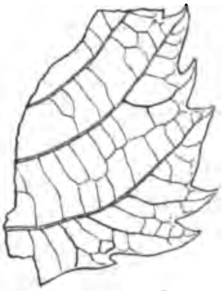

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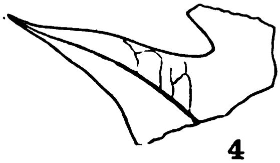

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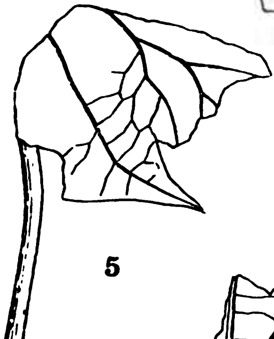

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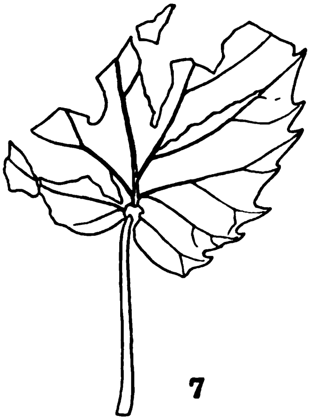

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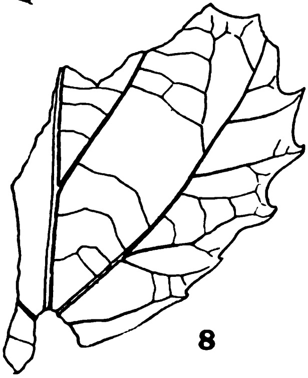

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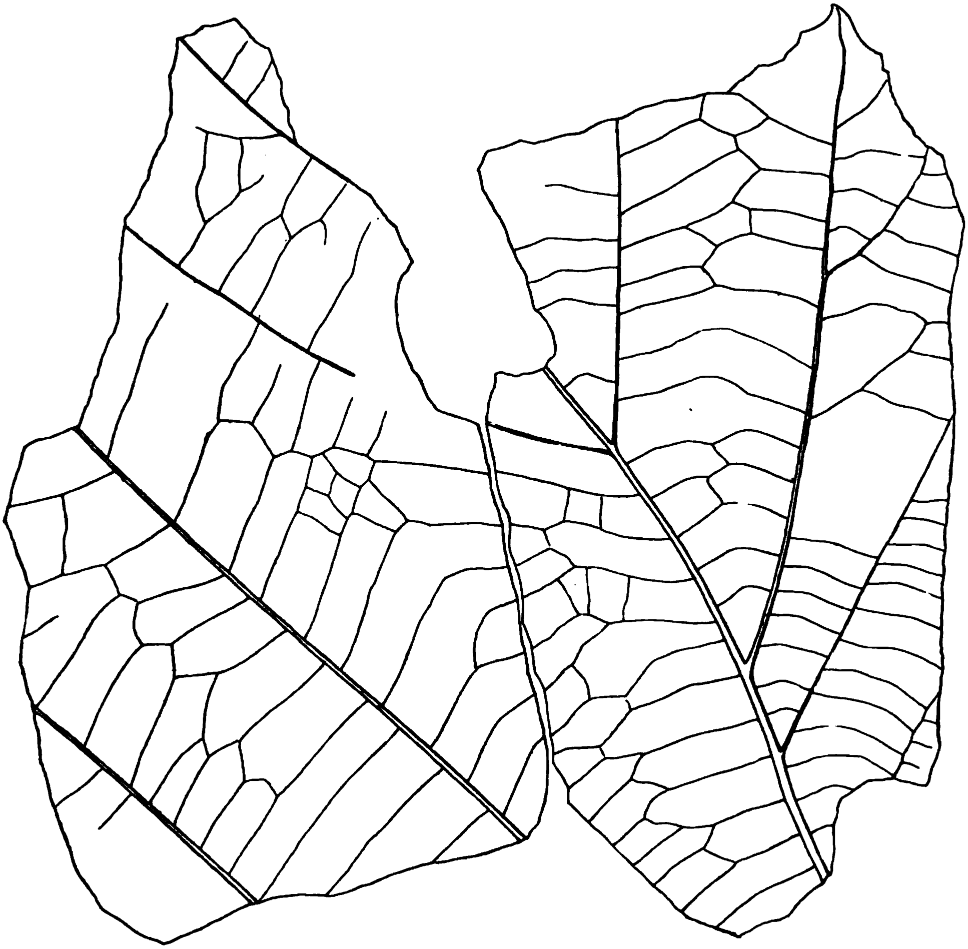

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TWO NEW CORALLINE ALGAE FROM CULEBRA, PORTO RICO

By M. FOSLIE and M. A. HOWE

NEW YORK
1906

[From the Bulletin of the Torrey Botanical Club 33: 577-580, *pl.* 23-26. 1906]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 33: 577-580. 1906.]

Two new coralline algae from Culebra, Porto Rico

M. FOSLIE AND M. A. HOWE

(WITH PLATES 23-26)

Since the publication of our paper on "New American Coralline Algae," * the island of Culebra, lying between Porto Rico proper and St. Thomas and now occupied by the United States as a naval station, has been visited by a collecting party from the New York Botanical Garden. Several coralline algae were secured there, including two rather large and conspicuous kinds which are quite different from any hitherto reported from the West Indian region and are, we think, entitled to characterization as new species. Descriptions of these two species are herewith given:

Goniolithon acropetum Fosl. & Howe, sp. nov.

Attached by a rather inconspicuous hypothallus and forming cespitose or difform masses mostly 4–12 cm. high, the single clusters usually 6–15 cm. in diameter, but often confluent and apparently larger; branches repeatedly subdichotomous, much anastomosed, compressed or subterete, 1.25–3.10 mm. in diameter, and subtruncate-capitate, or very often much dilated either at apex only or throughout and then forming flabella or foliar laminae 10–25 mm. broad (including anastomoses) and 1–2 mm. thick or commonly thicker in basal parts, the dilated portions often anastomosing in such a way as to form somewhat tubular or subinfundibuliform communicating interstices, the terminal flabella sometimes crested with short subterete or dentiform innovations; younger branches all conspicuously decutescent, the exfoliations papyraceous, revolute, and more or less concentric or zonate: medullary hypothallic cells 14–40 $\mu \times$ 11–20 μ; perithallic cells 11–21 $\mu \times$ 9–14 μ, heterocysts numerous; conceptacles of sporangia subconical becoming mammilliform, about 1 mm. in diameter; sporangia 4-parted, 90–168 $\mu \times$ 40–102 μ. (FIGURE 1 and PLATES 23, 24.)

Growing on corals and on other *Melobesieae* in about 1–4 dm. of water (low tide) in a reef-sheltered cove near the mouth of the main harbor of Culebra Island, Porto Rico (M. A. Howe, 3 March, 1906, *no. 4224*).

---

* Bull. N. Y. Botanical Garden 4: 128–136. *pl. 80–93.* 17 Mr 1906.

Goniolithon acropetum is probably most nearly allied to *Goniolithon frutescens* Fosl. f. *flabelliformis*, of the South Pacific, originally described * from Funafuti, but is evidently quite distinct from that species, being coarser,† more anastomosed, often much more widely dilated, and more conspicuously decutescent; the conceptacles of sporangia are somewhat larger (about 1 mm. diameter *vs.* 500–600 μ in *G. frutescens*) and are rather less abruptly conical, and the sporangia attain larger dimensions (reaching maxima of 168 μ in length and 102 μ in width *vs.* 110 μ and 50 μ in *G. frutescens*); the perithallic layer is thicker, and after decalcification the cells of both perithallium and medullary hypothallium appear more rounded at the angles and firmer-walled than in *G. frutescens.*

Conditions of *Goniolithon acropetum* with subterete branches sometimes bear a slight resemblance to forms of *G. strictum* Fosl., but are coarser, less fragile, and have less tapering branches. A small form of *G. strictum* was found growing within half a mile of *G. acropetum* and was always abundantly distinct.

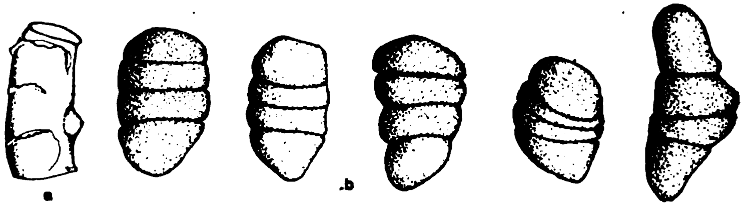


FIGURE 1. *Goniolithon acropetum; a*, end of a terete branch showing tetrasporangial conceptacle and exfoliations, × 5; *b*, tetraspores, × 150.

On the other hand, forms of *Goniolithon acropetum* with dilated, flabelliform branches have a certain superficial resemblance to *Lithophyllum platyphyllum* Fosl. (St. Martin, West Indies) and *Lithophyllum daedaleum pseudodentatum* Fosl. & Howe (Porto Rico), but have really no close affinity with either of these. Both of the last named forms are either not at all decutescent or flake off only minute and irregular scales.

---

* Det Kgl. Norske Videnskabers Selskabs Skrifter. No. 1. 1900.

† Compare published photographs of *G. frutescens* f. *typica*, in The Fauna and Geography of the Maldive and Laccadive Archipelagoes 1: *pl. 25. f. 4;* and in Corallinaceae Siboga-Exped. *pl. 10. f. 7–9.* 1904.

Lithophyllum Antillarum Fosl. & Howe, sp. nov.

Thallus grayish-pink or decolorate when living, becoming pallid or greenish-pallescent on drying, forming often somewhat columnar rather flat-topped masses 10–30 cm. high and 8–20 cm. broad; branches much fused, forming in the basal parts an almost solid mass with more or less lacunae, the irregular and somewhat daedaleoid anastomoses extending nearly to the irregularly pyramidal, somewhat prismatic, subconical, compressed or occasionally subterete, often truncate or retuse apices, the free portions mostly 5–25 mm. broad and 3–12 mm. thick, often enlarging upward, the interstices commonly tubular or irregularly infundibuliform; surface smooth or subpulverulent, or, especially at the sides, minutely corrugated or rugulose; medullary hypothallic cells 7–18 μ × 7–10 μ, sometimes forming (in a longitudinal section) irregularly alternating rows of one short and two long cells; perithallic cells subquadrate or roundish, 7–10 μ in diameter; short rows of larger cells (20–33 μ × 14–20 μ) occurring here and there in both medulla and perithallium: conceptacles of sporangia convex, but little prominent, 150–300 μ in diameter: sporangia 4-parted, 38–70 μ × 20–40 μ. (FIGURE 2 and PLATES 25, 26.)

Growing at low-water mark on a coral reef at Flamingo Bay, Culebra Island, Porto Rico (M. A. Howe, 7 March 1906, *no. 4373*).

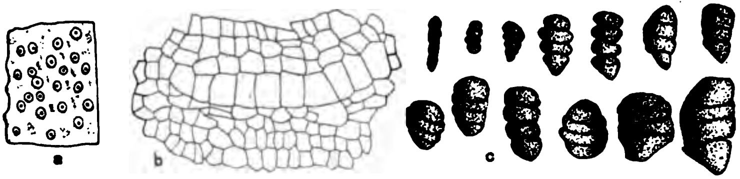


FIGURE 2. *Lithophyllum Antillarum*; *a*, portion of surface with tetrasporangial conceptacles, × 5; *b*, portion of a radio-vertical section, showing row of enlarged cells × 232 (the cells should be more rounded at the angles, as indicated in photomicrograph, PLATE 26); *c*, tetraspores, × 150.

Lithophyllum Antillarum is evidently a reef-builder. In general habit it bears some resemblance to coarse forms of *Lithophyllum africanum* Fosl. (Cape Verde) and to well-developed conditions of *Lithophyllum craspedium* Fosl., a species originally described from specimens brought from Funafuti and since discovered in the Maldives (see Fauna and Geography of the Maldive and Laccadive Archipelagoes, 1: *pl. 25. f. 1*). It is perhaps the more closely related to the latter species, agreeing essentially in structure even to the possession of the peculiar short rows of enlarged cells apparent at frequent intervals in a radio-longitudinal section (FIGURE 2, *b* and PLATE 26; see also Corallinaceae Siboga-Exped. 59), but the West Indian plant is rather coarser and is considerably different in habit as will be seen by comparing our photograph (PLATE 25) with that of *L. craspedium* cited above, the branches being more inclined to increase in size upward and anastomosing in a more gyrose or daedaleoid fashion. We believe it should bear a distinctive specific name, at least until further collections give better grounds for understanding the relationships of West Indian forms to those of the South Pacific and Indian oceans. *Lithophyllum africanum* is less coarse than *L. Antillarum*, its branches are thinner, and more frequently subterete or compressed, though sometimes dilated and rather foliar, its medullary cells after decalcification are firmer-walled and more rounded at the angles, and the short rows of enlarged cells are rare.

Explanation of plates 23-26

PLATE 23

Goniolithon acropetum, natural size; the topmost specimen is the type.

PLATE 24

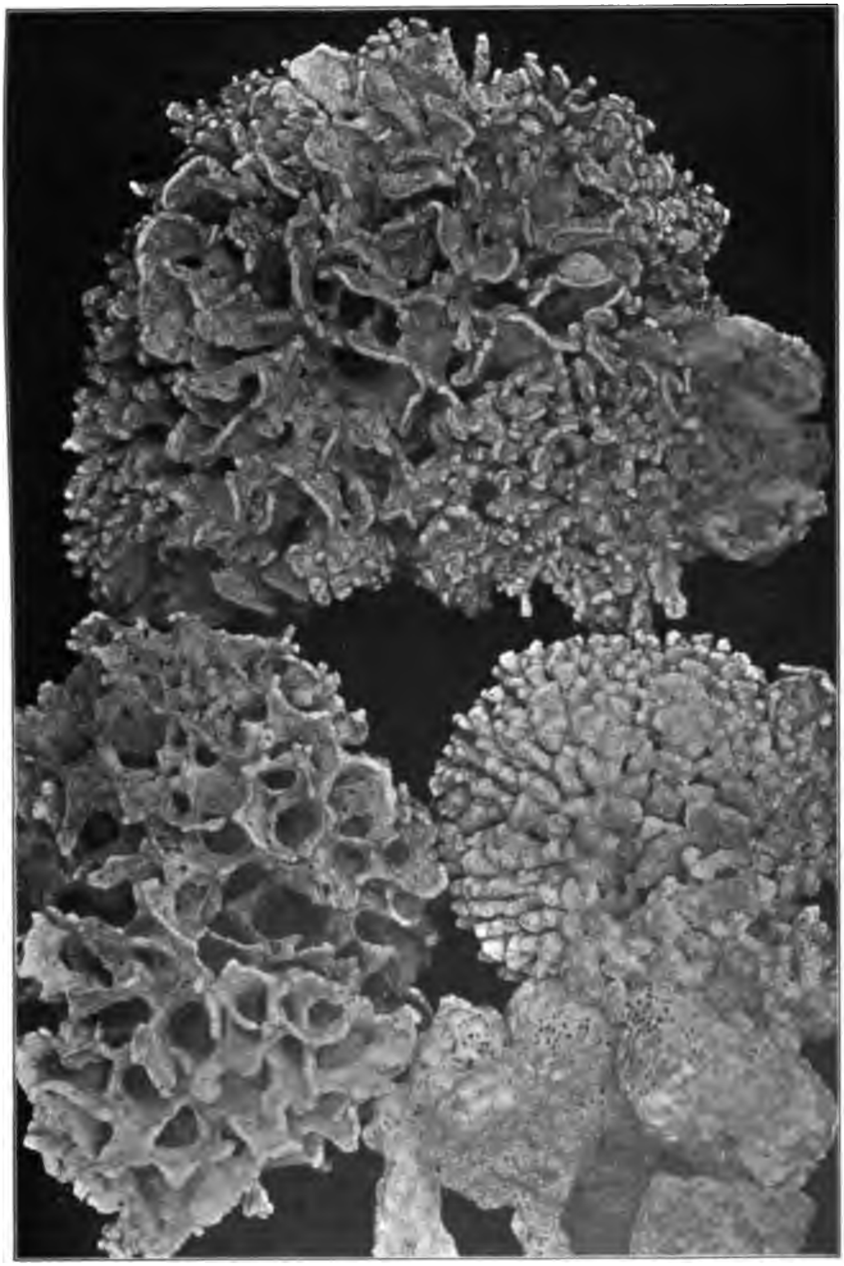
Goniolithon acropetum. Photograph of a sagittal section (decalcified) of a flattened branch, showing perithallium and portion of medullary hypothallium, magnified 165 diameters.

PLATE 25

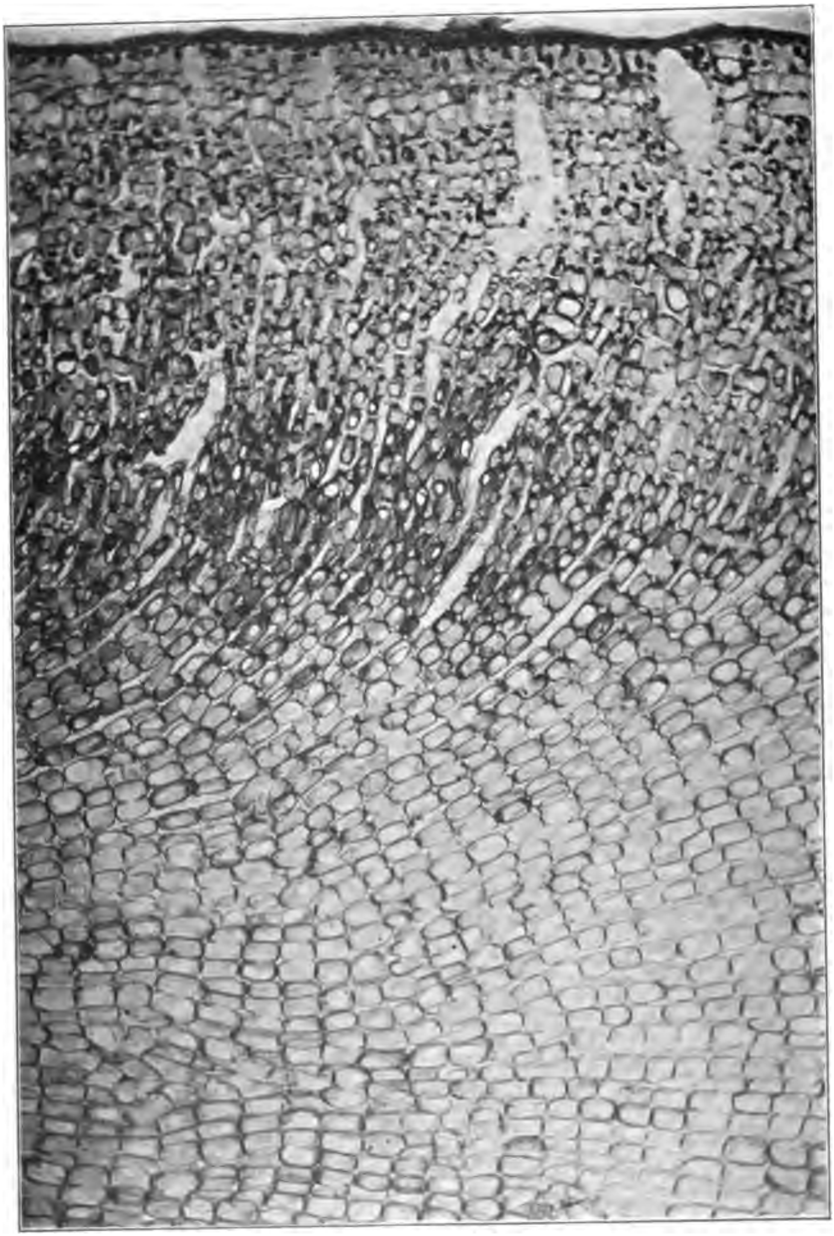
Lithophyllum Antillarum, natural size, the upper specimen seen from above, the lower from the side; the latter the type.

PLATE 26

Lithophyllum Antillarum. Photograph of radio-vertical section (decalcified) from the medullary hypothallium, magnified 165 diameters. The direction of growth is towards the upper left-hand corner.



GONIOLITHON ACROPETUM Fosl. & Howe.



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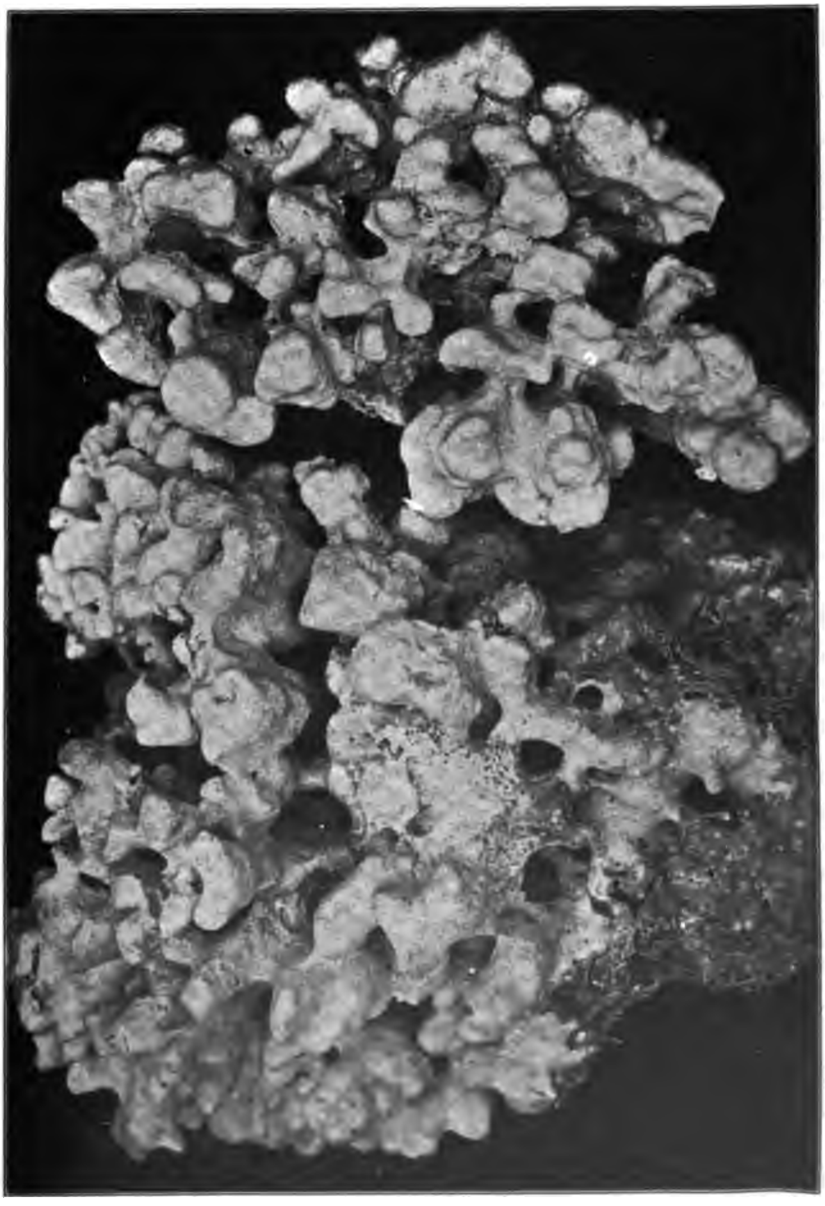
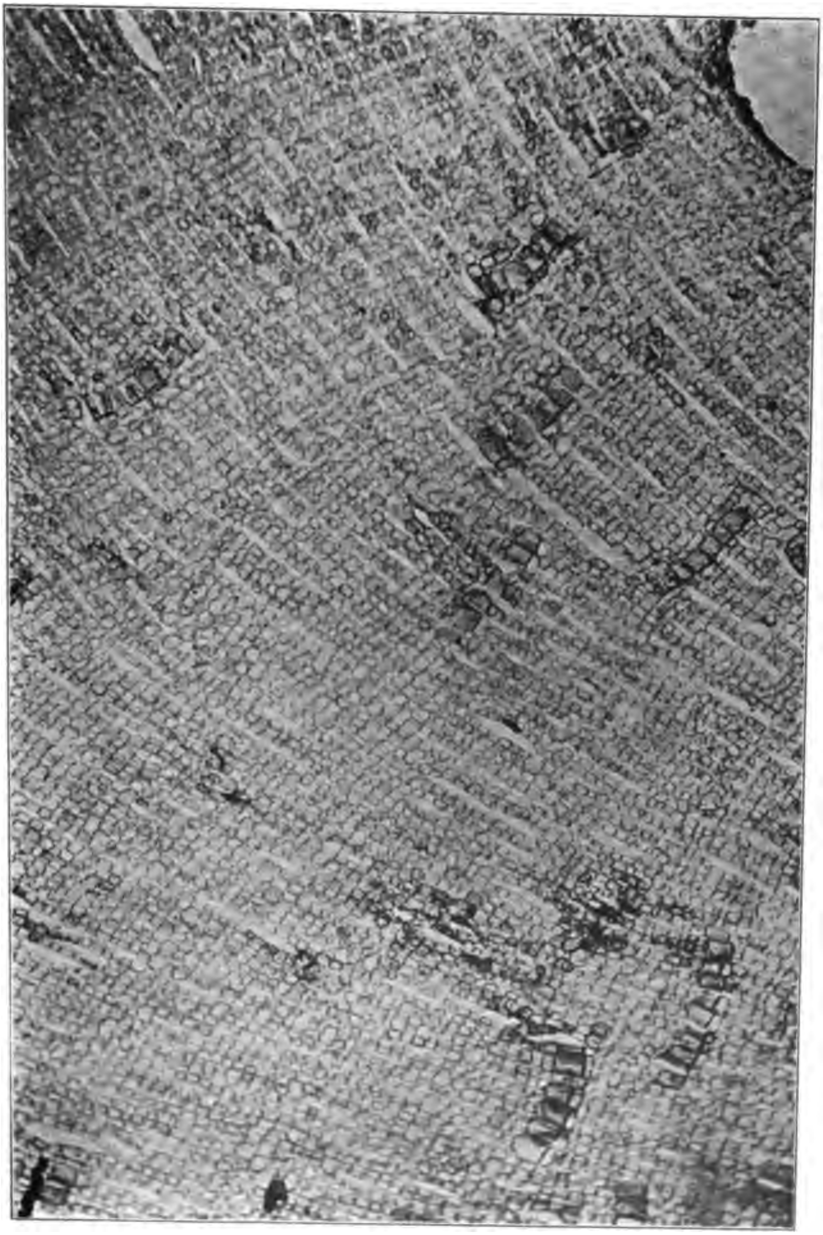


LITHOPHYLLUM ANTILLARUM Fosl. & Howe.



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STUDIES ON THE ROCKY MOUNTAIN FLORA—XVII

By PER AXEL RYDBERG

NEW YORK
1907

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 35–50. 1907]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 34: 35-50. 1907.

Studies on the Rockv Mountain flora — XVII

PER AXEL RYDBERG

Pedicularis siifolia

Perennial with a rootstock; stem glabrous, 3–6 dm. high, leafy; leaves pinnately divided to the midrib, glabrous, 5–15 cm. long; divisions lanceolate, narrowed at the base, 1–4 cm. long, more or less doubly serrate-dentate; spike short, 3–8 cm. long; bracts linear, oblong, or lanceolate, entire or slightly toothed; calyx glabrous or with a few scattered hairs, 8–9 mm. long, its lobes lanceolate; corolla yellowish, nearly 2 cm. long; galea about 8 mm. long, curved, upper portion helmet-shaped with a short conical beak; lip 4 mm. long, rather deeply 3-cleft with rounded lobes.

This species is somewhat intermediate between *P. Canbyi* and *P. bracteosa.* In habit it resembles closely the latter, but the corolla is that of the former, having an evident although short beak. It grows in the mountains of western Montana and Idaho at an altitude of 600–1200 m.

MONTANA: Grant Creek, June 7, 1897, *M. J. Elrod and assistants 97.*

Adenostegia ciliosa

Annual; stem more or less branched, puberulent, purplish, 1.5–2 dm. high; leaves 2–3 cm. long, finely puberulent, 3–5-cleft into filiform divisions; flowers in small headlike clusters; bracts similar to the leaves but with broader bases and more or or less hirsute-ciliate with white flat hairs; calyx nearly 1.5 cm. long, more or less ciliate; its divisions about 5-ribbed; corolla about 15 mm. long; galea 5–6 mm. long, hooded at the apex; lip nearly as long, pubescent without; stamens 4, anthers 2-celled, sparingly short-bearded.

This species is probably most closely related to *A. ramosa* Nutt., but is easily distinguished by the ciliate bracts and calyces. It grows on dry mesas at an altitude of about 2000 m.

WYOMING: Spread Creek, 1897, *Frank Tweedy 545.*

Castilleja arcuata

Perennial, more or less tufted at the base; stems erect, strict, usually simple, 2–4 dm. high, shining, yellow or tinged with purple, glabrous or short-villous in the inflorescence; leaves narrowly linear, 2–6 cm. long, 1–3 mm. wide, glabrous or the lower sparingly white-villous; bracts brownish, 1–2 cm. long, 3-cleft with lanceolate lobes, white-villous with short hairs; calyx 12–15 mm. long, deeply cleft below, less deeply so above, its lobes lanceolate, about 1 mm. long; corolla 2.5–3 cm. long, at last strongly curved, greenish with yellow margins; galea 12–15 mm. long; lip about 3 mm. long, with linear-lanceolate lobes.

This species is related to *C. cognata* and *C. linariaefolia.* From the former it differs in the color of the bracts, different pubescence and the more arching corolla, from the latter in the color of the bracts, the lower habit and the smaller corolla. It grows in meadow land with alkaline soil.

UTAH: South end of Fish Lake, August 10, 1905, *Rydberg & Carlton 7508.*

Castilleja magna

Perennial; stem a meter or so high, glabrous and shining, angled; leaves lanceolate, 4–6 cm. long, glabrous, 5-ribbed and reticulate, more or less acuminate; inflorescence short and dense; bracts ovate, entire, tipped with crimson, as well as the axis of the inflorescence viscid-ciliate; calyx about 2.5 cm. long, cleft halfway down both above and below, its lobes lanceolate, acuminate, 4–5 mm. long; corolla 4–5 cm. long, greenish, tinged with crimson and with crimson margins; galea fully 2 cm. long; lip about 3 mm. long, its lobes lanceolate.

This species somewhat resembles *C. rhexifolia,* but is a taller plant, with smaller bracts and much larger corolla. The latter is of about the size of that of *C. Suksdorfii,* which however is a much smaller and more pubescent plant and has narrow leaves.

BRITISH COLUMBIA: Trail above Carbonate, 1904, *Charles H. Shaw 205.*

Castilleja Leonardi

Perennial, with a short woody caudex; stems several, 2–3 dm. long, more or less viscid-villous; leaves ovate-lanceolate or oblong-lanceolate, 1.5–3 cm. long, densely puberulent, 3-ribbed, acute or acuminate; bracts broadly ovate or obovate, rounded at the apex, about equaling the flowers, densely pubescent, entire, tipped with crimson; calyx 1.5 cm. long, densely puberulent, equally cleft above and below, its lobes ovate, 1.5–2 mm. long, obtuse; corolla 2 cm. long or less, densely puberulent; galea about 1 cm. long; lower lip about 2 mm. long, its lobes lanceolate.

This species is related to *C. lauta* and *C. rhexifolia.* From the former it differs in the broad leaves and dense pubescence, and from the latter in the small size of both the plant and the flower, the thick leaves and more copious pubescence.

UTAH: Head of American Fork Cañon, 1885, *F. E. Leonard 151* in part (type); mountains around the south fork of Big Cottonwood Creek, 1905, *Rydberg & Carlton 6592.*

Castilleja humilis

Perennial, with a short woody caudex; stems several, about 2 dm. high, glabrous below, somewhat viscid-pubescent above; leaves oblong to elliptic-lanceolate or the uppermost ovate, 2–3 cm. long, obtuse or acute, finely puberulent; bracts entire, obovate, tipped with dark crimson, a little shorter than the corollas; inflorescence short and dense; calyx densely puberulent, 10–12 mm. long, equally cleft above and below, its lobes ovate, obtuse, about 1.5 mm. long; corolla about 15 mm. long, densely puberulent, greenish with purple margins; galea 7–8 mm. long; lip 2 mm. long, its lobes lanceolate, acuminate.

In habit this species most resembles *C. rhexifolia,* but the plant is much smaller and the corolla of about half the size. It grows in alpine woods.

WYOMING: Medicine Bow Mountains, Albany County, 1900, *Aven Nelson 7919.*

Castilleja variabilis

Perennial with a rootstock; stems usually single, more or less pubescent, 4–8 dm. high; leaves linear-lanceolate or lanceolate, 4–6 cm. long, 3-ribbed, puberulent and more or less short-hirsute, rarely glabrous; bracts lanceolate, deeply 3-cleft, greenish at the base, otherwise yellow with scarlet or brick-red tips or sometimes almost wholly brick-red; calyx viscid-villous, about 2.5 cm. long, tinged with yellow; corolla yellowish-green with scarlet or yellow margin, about 4 cm. long; galea nearly 2 cm. long; lip dark-green, 3 mm. long, with lanceolate lobes.

This species somewhat resembles *C. lanceolata,* but has larger flowers and differently colored bracts. These are nearly of the same color as those of *C. lutescens* and *C. desertorum,* but both of these species have smaller flowers and 3-cleft upper leaves. *C. variabilis* grows in mountain valleys and on hillsides, at an altitude of 2500–3000 m.

UTAH: Big Cottonwood Cañon, below Silver Lake, 1905, *P. A. Rydberg 6773* (type) and *6800;* divide between Big Cottonwood Cañon and Heber Valley, 1905, *Rydberg & Carlton 6646;* Big Cottonwood Cañon, 1905, *A. O. Garrett, 1504.*

Castilleja Vreelandii

Perennial with a rootstock; stem usually single, 6–8 dm. high, glabrous or nearly so, shining; leaves lanceolate, 3–5-ribbed, glabrous or nearly so, 4–6 cm. long, somewhat acuminate; bracts lanceolate, usually 3-lobed with acute lobes, tipped with crimson; calyx 2–2.5 cm. long, tinged with crimson, equally cleft, viscid-villous below, puberulent above, its lobes lanceolate, acute, 6–8 mm. long; corolla dark-green with purplish margins; galea about 2 cm. long; lower lip 2 mm. long, with lanceolate teeth.

This species is related to *C. lanceolata,* but differs in the larger flowers and the broader, almost glabrous leaves. It grows in the mountains from Montana and Idaho to Wyoming and Utah. As the type is regarded the following:

MONTANA: Divide between McDonald and Camas Lakes, 1901, *F. K. Vreeland 1000.*

Castilleja purpurascens

Perennial with a short caudex; stems several, 1–3 dm. high, glabrous or slightly puberulent, villous above, usually dark-purple; leaves narrowly linear, finely puberulent, 3–5 cm. long, 2–3 mm. wide; inflorescence short and dense; bracts lanceolate, acute or obtuse, the lower usually entire, the upper more or less cleft, tipped with crimson; calyx 15–20 mm. long, more or less villous, especially towards the base, equally cleft, its lobes 2–3 mm. long, obtuse; corolla 2.5–3 cm. long, green with crimson margins; galea about 1 cm. long; lower lip 3 mm. long, with narrowly lanceolate lobes.

This is probably most closely related to *C. Tweedyi* and *C. miniata,* but differs in the lower habit, the darker coloration of the bracts, the narrow leaves, obtuse calyx-lobes, and usually purplish stem.

BRITISH COLUMBIA: Flood-plains of Kicking Horse, 1904, *H. Peterson 11* (type).

ALBERTA: National Park, Banff, 1897, *Mr. & Mrs. C. Van Brunt 40;* Pipestone Pass, 1904, *J. Macoun 67803.*

Castilleja viscida

Cespitose perennial with a short woody caudex; stems 1–3 dm. high, viscid- or glandular-puberulent and with scattered crisp white hairs; leaves 1.5–3 cm. long, 3–5-cleft at the middle, densely glandular-puberulent, the body lanceolate, 3-ribbed, the lobes narrowly lanceolate and directed forward; bract similar to the leaves, tipped with crimson or scarlet; calyx equally deeply cleft above and below, 18–20 mm. long, its lobes lanceolate, 5 mm. long, acuminate or acute; corolla about 2.5 cm. long, dark-green, with crimson margin; galea about 1 cm. long; lip 3 mm. long, its lobes lanceolate.

This species is related to *C. hispida*, *C. Bradburyi* and *C. rupicola*. From the first two it differs in the lower habit and viscid or glandular pubescence, and from the last one in the shorter galea. It grows in the mountains among rocks at an altitude of 2700–3300 m.

UTAH: Mountains near the headwaters of Big Cottonwood Creek, 1905, *Rydberg & Carlton 6593* (type), *6565*, *6540*, *6554*, *6635* and *6546*; Mount Nebo, *no. 7703*, *7750* and *7755*.

Castilleja ampliflora

Perennial, cespitose and somewhat woody at the base; stems 3–4 dm. high, usually branched, ascending, puberulent and somewhat villous; most of the leaves entire, lanceolate, 2–3 cm. long with a short and rather dense pubescence; the upper 3–5-lobed, the middle lobe being broad and the lateral ones small; bracts 3-lobed with a broad rounded middle lobe, crimson, 1–1.5 cm. long; calyx 1.5–2 cm. long, villous, equally cleft above and below, its lobes 3–4 mm. long; corolla nearly 3 cm. long, more turgid than usual; galea fully 1.5 cm. long; lip 3 mm. long, with lanceolate lobes.

This is perhaps most closely related to *C. Bradburyi*, but the stems are more branched, the corolla more turgid, the leaves more inclined to be entire, and the galea fully as long as the corolla-tube. It grows at an altitude of 1150–1350 m.

MONTANA: Divide between McDonald and Camas Lakes, July 29, 1901, *F. K. Vreeland 995*.

Castilleja gracillima

Perennial with a rootstock; stems usually solitary, slender, purplish, 2–4 dm. high, sparingly villous; leaves linear-lanceolate, 2–4 cm. long, 3-ribbed, sparingly short-villous; bracts ovate, entire, toothed or 3-cleft, rose or brownish, puberulent, villous-ciliate; calyx about 15 mm. long, equally cleft above and below, its lobes lance-oblong, obtusish, 3 mm. long; corolla purplish, slightly longer than the calyx; galea 8 mm. long; lip about 3 mm. long, its lobes ovate.

This species is closely related to *C. pallida*, but differs in the leaves, which are shorter, neither long-attenuate nor falcate, and in the different color of the bracts and corolla.

In mountain meadows especially on the geyser formations at an altitude of 2000–2700 m.

WYOMING: Lower Geyser Basin, Yellowstone Park, 1897, *Rydberg & Bessey 4964* (type); Lone Star Geyser Basin, *no. 4961*; Upper Hoback Basin, 1900, *C. C. Curtis.*

MONTANA: Mountains near Indian Creek, 1897, *Rydberg & Bessey 4967.*

ALBERTA: Vicinity of Banff, 1899, *W. C. McCalla 2187.*

Castilleja parvula

Cespitose perennial with a short caudex; stems many, 5–15 cm. high, puberulent; leaves lanceolate, 1–2 cm. long, puberulent; bracts ovate, dark brownish-crimson, finely puberulent, entire or with short lobes; calyx 12–14 mm. long, puberulent, equally cleft above and below, its lobes oblong, obtuse, 2–3 mm. long; corolla 17–18 mm. long, greenish with purplish margins; galea about 7 mm. long; lip 2.5–3 mm. long, its lobes lanceolate.

This species is closely related to *C. occidentalis*, but differs in the bracts, which are darker, of a deep crimson shade and not at all villous, and also in the corolla, which is decidedly greenish and with a shorter lip. It grows among rocks on high mountains, at an altitude of nearly 3000 m.

UTAH: Mountains north of Bullion Creek, near Marysvale, 1905, *Rydberg & Carlton 7158* (type) and *7090.*

Castilleja pulchella

Perennial with a cespitose caudex; stems 5–15 cm. high, ascending, more or less villous especially above; leaves 1–4 cm. long; the lower entire and linear-lanceolate, the upper broader and 3-cleft, puberulent and slightly villous; lobes linear-lanceolate, attenuate; bracts elliptic, usually 3-cleft, the middle lobe broad and rounded, tinged with brownish, villous; calyx yellowish, tipped with brownish, about 18 mm. long; lobes very short and rounded; corolla slightly exserted; galea 7 mm. long; lip 5 mm. long, its lobes lanceolate, obtuse.

This species is intermediate between *C. lutea* and *C. occidentalis.*

It has the habit, pubescence and coloration of the latter but the leaves, bracts and calyx-lobes of the former; the form of the corolla is intermediate between those of the two. *C. pulchella* grows on high mountains at an altitude of 2500–3300 m.

MONTANA: Mountains near Indian Creek, 1897, *Rydberg & Bessey 4967* (type); Electric Peak, *no. 4968.*

WYOMING: Big Horn Mountains, 1899, *Tweedy 2345;* Dome Lake, 1896, *Aven Nelson 2435;* Teton Forest Reserve, 1897, *Tweedy 247.*

Castilleja Pecten

Perennial; stem stout, 4–5 dm. high, puberulent throughout; lower leaves linear, entire, 5–6 cm. long, puberulent; the upper 3–5-cleft with linear divisions; bracts rhombic-obovate or broadly cuneate in outline, almost pectinately cleft into linear divisions, puberulent, upper portion yellowish or the tips brownish; calyx about 2 cm. long, puberulent, equally cleft above and below; lobes lanceolate, about 3 mm. long; corolla a little over 2 cm. long; galea 8–9 mm. long; lip about 4 mm. long, its lobes oblong.

In general habit and coloration it resembles somewhat *C. desertorum* and *C. lutescens*, but the lower lip is nearly half as long as the galea and of different shape, and the bracts are peculiar. The structure of the corolla places this species nearest to *C. fasciculata*, but it is a much larger plant.

IDAHO: Beaver Cañon, 1895, *C. L. Shear 3041* (type) and *3038.*

Lupinus marianus

Stem 5–10 dm. high, striate, hirsute-villous with rather short hairs, slender, leafy; stipules setaceous; petioles 4–8 cm. long, or those of the basal leaves even 2 dm. long, hirsute-villous; leaflets 6–8, narrowly oblanceolate, 3–7 cm. long, acute, glabrous above, appressed, short-hairy beneath; inflorescence lax, 1–1.5 dm. long; pedicels 4–5 mm. long; calyx villous, gibbous but not spurred at the base on the upper side; lips lanceolate, the upper 7 mm., the lower 8 mm. long; bracts linear-subulate, longer than the calyx, deciduous; banner 8–10 mm. long, light-blue or white with a darker spot; wings light-blue or white, 10–12 mm. long; legume 3–4 cm. long, 8–9 mm. wide, densely pubescent.

In habit resembling *L. pseudoparviflorus* and *L. laxiflorus*, but differing in the spreading pubescence of the stem. This character would associate it with *L. amplus* and *L. ornatus glabratus* S. Wats. From the former it differs in the lax spike, slender stem, and the paler and smaller corolla; from the latter in the long linear-subulate bracts and narrow leaflets.

UTAH: Along Bullion Creek, above Marysvale, July 21, 1905, *Rydberg & Carlton 7024* (type) and *7025*.

Lupinus stenophyllus (Nutt.)

Lupinus foliosus stenophyllus Nutt.; T. & G. Fl. N. Am. **1**: 377 (synonym). 1840.

Stem slender, probably 1 m. high, finely silky-strigose; stipules small, subulate; petioles of the stem-leaves about 3 cm. long, strigose; leaflets about 5, narrowly linear-oblanceolate, about 3 cm. long, 4 mm. wide, usually conduplicate, acute, green, glabrous above, sparingly silky-strigose beneath; raceme about 1 dm. long, lax, more or less one-sided; bracts lanceolate, shorter than the calyx, deciduous; calyx densely silky-strigose, more or less spurred at the base; upper lip ovate, 4 mm. long, the lower lanceolate, 6 mm. long; corolla light-blue, 7–8 mm. long; banner slightly shorter than the broad wings; fruit unknown.

This species has been included in *L. laxiflorus* and *L. tenellus*. It resembles the latter in habit but differs in the spurred calyx and green leaves. From the former it differs in the narrower leaves, glabrous above, and the smaller flowers. The type was collected on the "Oregon Plains" by Nuttall.

Lupinus laxispicatus

Perennial; stems 3–4 dm. high, slender, striate, sparingly strigose; stipules small, lanceolate; petioles strigose, 5–15 cm. long; leaflets 7–10, narrowly oblanceolate, acute, green, glabrous above, strigose beneath, 4–5 cm. long, about 6 mm. wide; inflorescence lax, rather few-flowered; bracts lanceolate, shorter than the calyx, deciduous; calyx grayish silky-strigose, gibbous; lips lanceolate, the upper 6 mm., the lower 7 mm. long; corolla blue, about 10 mm. long; banner only slightly shorter than the wings.

This species is nearest related to *L. Scheuberae*, which however has broader leaves, larger flowers and the upper lip of the calyx is ovate and much shorter than the lower. *L. laxispicatus* grows on high mountains.

IDAHO: Kootenai County, July, 1887, *J. H. Sandberg*.

Lupinus Macounii

Perennial with a short caudex; stems several, 3–6 dm. high, silky-strigose, somewhat branched; stipules lance-subulate; petioles

2–5 cm. long, strigose; leaflets about nine, linear-oblanceolate, 2–3 cm. long, usually conduplicate, silky-strigose on both sides; racemes dense, 5–10 cm. long; bracts narrowly lanceolate, not exceeding the buds, deciduous; calyx gibbous at the base, short-silky with spreading hairs; lower lip lanceolate, 6–7 mm. long, the upper hardly 4 mm. long, ovate; corolla 8–9 mm. long, dark-blue, the banner with a lighter spot, somewhat shorter than the wings; legume densely silky, villous, about 2 cm. long, 6 mm. broad, 3–4-seeded.

The type was labeled *L. argenteus argophyllus.* Its relationship is closer however to the true *L. argenteus*, differing in the smaller, darker flowers, the spreading pubescence on the calyx and pedicels and above all in the shorter upper lip of the calyx. It grows at an altitude of 1000–2500 m.

SASKATCHEWAN: Cypress Hills, 1894, *John Macoun 4070* (type in herb. Columbia Univ.).

MONTANA: Spanish Peaks, 1896, *Flodman 629* (in part).

WYOMING: Big Horn Mountains, 1899, *Tweedy 2363*; Leckie, 1901, *Merrill & Wilcox 759.*

Lupinus subulatus

Perennial with a short caudex; stem 4–5 dm. high, densely silky-strigose, striate, leafy; stipules subulate; petioles silky-strigose, 3–6 cm. long; leaflets 7–10, narrowly oblanceolate or linear-oblanceolate, densely appressed, silky on both sides, 2–4 cm. long, cuspidate or mucronate; raceme dense, 1–1.5 dm. long; bracts subulate-setaceous, much exceeding the buds; calyx appressed silky-canescent, scarcely gibbous; lower lip 8 mm. long, narrowly lanceolate, the upper ovate-lanceolate, 6 mm. long; corolla dark-blue with keel and a spot on the banner light-colored, about 1 cm. long; petals subequal, banner rather densely pubescent without.

This is related to *L. holosericeus*, *L. canescens*, and *L. oreophilus*, but easily distinguished by the long subulate-setaceous bracts.

MONTANA: Columbia Falls, June 3, 1897, *R. S. Williams* (type).

WASHINGTON: Spokane, 1898, *Piper 2823*; also 1892, *Henderson.*

Lupinus flavicaulis

Perennial with a short caudex; stems several, with erect branches, densely pubescent with short yellowish spreading hairs, almost velutinous, 3–5 cm. high; stipules subulate; petioles 2–4 cm. long, velutinous; leaflets 7–10, narrowly oblanceolate, usually conduplicate, densely silky on both sides, acute, 2–4 cm. long; racemes dense, 5–10 cm. long; bracts subulate, shorter than the buds; calyx gibbous, villous; lower lip lanceolate, 7 mm. long; upper lip ovate, 5–6 mm. long; corolla about 10 mm. long, light-purple or pink; banner with a darker spot, pubescent without; legume 2–2.5 cm. long, 7 mm. wide, densely silky-villous, 3–4-seeded.

In general habit, size, form, and color of the corolla and leaflets, this resembles *L. decumbens* very closely, but differs in the dense, short, spreading pubescence of the stem and the denser, longer, looser pubescence of the leaves. These characters place it in the same group as *L. Bakeri* and *L. dichrous*, which it otherwise little resembles. It grows on dry plains and hills.

WYOMING: Snake River, 1894, *Aven Nelson 1098* (type in herb. Columbia Univ.); Evanston, 1882, *N. L. Britton.*

UTAH: Divide, 1898, *Isabel Mulford 268.*

Lupinus macrostachys

Perennial with a short caudex; stem 5–10 dm. high, puberulent and with long silky spreading or reflexed hairs; stipules setaceous; petioles short-pubescent with spreading hairs, 2–10 cm. long; leaflets 7–8, linear-oblanceolate, acuminate, 3–6 cm. long, appressed-silky on both sides, grayish-green; raceme dense, 2–3 dm. long; bracts lanceolate, acuminate. merely equaling the buds; calyx velutinous, gibbous; lower lip broadly lanceolate, obtuse, about 8 mm. long; upper lip ovate, almost as long; corolla 10–12 mm. long, dirty-white, tinged with blue; banner with a darker spot; legumes fully 2 cm. long, densely silky-villous, 4–5-seeded.

This species is related to *L. leucophyllus*, from which it differs in the less dense and strictly appressed silky pubescence (scarcely canescent) and the color of the flowers. In *L. leucophyllus* they are rather light-blue or pink with darker striations (rarely white), the banner with a lighter spot. It grows at an altitude of about 1000 m.

MONTANA: Jocko Creek, 1901, *D. T. MacDougal 253* (type in herb. N. Y. Bot. Gard.).

Lupinus roseolus

Perennial with a cespitose caudex; stems ascending or decumbent, about 1 dm. high, sparingly strigose, 3–5-leaved, slender;

stipules setaceous; petioles 1–3 cm. long, slender, usually red-tinged; leaflets about 7, narrowly linear-oblanceolate, acute, 1–2 cm. long, sparingly silky, short-strigose; raceme 2–4 cm. long; bracts subulate, shorter than the buds; calyx gibbous, silky with short spreading hairs; lips broadly lanceolate, subequal, 5–6 mm. long; corolla nearly white, tinged with rose, about 8 mm. long; pod densely silky, perhaps 1.5 cm. long when fully developed.

This resembles *L. argenteus* in the form and color of the flowers. It has also the peculiar hue and pubescence of that species, but it is a much smaller plant and of a different habit. The latter will place it near *L. Lyallii.* It is an alpine plant growing at an altitude of 3000 m.

WYOMING: Continental Divide, Buffalo Fork, August 1897, *F. Tweedy 270.*

Lupinus scaposus

Annual, with sessile clasping cotyledons; stem branched at the base, 1–1.5 cm. high, sparingly ciliate; stipules lanceolate, acuminate; petioles 3–5 cm. long, ciliate, slender; leaflets about 7, spatulate, 1 cm. long, sparingly silky-hirsute on both sides or glabrous above; peduncles longer than the leaves, ciliate; raceme short, 1–4 cm. long; bracts lanceolate, short; calyx ciliate, the lower lip broadly lanceolate, entire, 5 mm. long, the upper 2-cleft, ovate; corolla purplish, 6 mm. long, paler at the base; banner shorter than the wings; legume ciliate, 1 cm. long, 6 mm. wide, 2-seeded.

In habit mostly resembling *L. brevicaulis* but more evidently caulescent, with longer peduncles. The most distinctive characters, however, are the different calyx and its entire lower lip. This associates it with *L. pusillus,* from which it differs in the long peduncles and smaller flowers.

COLORADO: Glenwood Springs, 1899, *Geo. E. Osterhout.*

Lupinus rubens

Annual, with sessile, clasping cotyledons; stem ciliate, tinged with red, branched near the base, about 1 dm. high; petioles densely ciliate, 2–4 cm. long; leaflets 6–7, spatulate, 1–1.5 cm. long, ciliate on both sides or glabrous above, acute; raceme lax, 5–10 cm. long, overtopping the leaves; bracts minute, subulate; calyx ciliate, the lower lip lanceolate, 5 mm. long, the upper barely 3 mm. long; corolla 7 mm. long; banner dark-purple with a yellow spot; wings and keel lighter, tinged with lilac.

This species is related to *L. pusillus*, but differs in the more elongated racemes, which much exceed the leaves, the smaller flowers of a different color and the short upper lip of the calyx.

UTAH: Southern Utah, 1874, *Parry 41* (type in herb. Columbia Univ.); St. George, 1877, *Palmer 86.*

Trifolium confusum

Perennial with a rootstock; stems erect, simple, 2–3 dm. high, glabrous below, sparingly strigose above; stipules ovate, acute, about 2 cm. long, glabrous, veiny; leaflets of the lower leaves oval and rounded at the apex, of the upper ones lanceolate, and acute, 2–3 cm. long, finely denticulate, glabrous or nearly so; peduncles 5–7 cm. long; head globose; flowers reflexed in fruit; calyx-tube 2 mm. long, glabrous except the villous margin; teeth villous, 4–5 mm. long, subulate-setaceous; corolla rose or purplish, 13–15 mm. long; ovary 4-ovuled; legume sparingly hairy, stipitate.

This species belongs to the *T. longipes* group. It is probably most nearly related to *T. Rydbergii* and *T. pedunculatum.* From the former it differs in the nearly glabrous calyx-tube and the rose-colored and larger corollas; from the latter in the larger and reflexed flowers. It differs from *T. longipes* and *T. Rusbyi* in its different habit and nearly glabrous calyx.

SOUTHERN UTAH: 1874, *C. C. Parry 35* (type in herb. Columbia Univ.).

Trifolium Aitonii

Perennial with a rootstock; stem 3–4 dm. high, glabrous below, strigose above; stipules ovate, short-acuminate, about 2 cm. long, veiny; leaflets ovate, thin, obtuse or rounded and mucronate at the apex, finely denticulate, 2–4.5 cm. long, glabrous above, sparingly hairy beneath; peduncles several, 1–2 dm. long; heads globose; flowers reflexed in fruit on pedicels 2–3 mm. long; calyx pubescent throughout; tube 2 mm. long; teeth subulate, about 4 mm. long; corolla about 12 mm. long; legume stipitate, strigose, about 2-seeded.

This species is related to *T. latifolium*, from which it differs mainly in the different habit, larger size, longer peduncles and larger ovate instead of oval or obovate leaflets.

IDAHO: Palouse County, 1892, *G. B. Aiton 65* (type in herb. N. Y. Bot. Gard.).

Trifolium uintense

Trifolium dasyphyllum S. Wats. Bot. King Exp. 60, in part. 1871. Not *T. dasyphyllum* Torr.

Cespitose, subacaulescent perennial; stipules large and scarious; petioles 1–4 cm. long, sparingly strigose; leaflets oblanceolate, broadest above the middle, acute and mucronate, entire, 1–2 cm. long, sparingly pubescent or glabrate above; peduncle about 6 cm. long, sparingly strigose; head obovate, rather few-flowered; bracts lanceolate, 5–8 mm. long, 3-nerved, slightly if at all scarious-margined; calyx only slightly pubescent; tube 2.5 mm. long; teeth subulate-setaceous, about 7 mm. long; corolla purple, about 15 mm. long; ovary pubescent, about 6-ovuled.

This is a member of the *T. dasyphyllum* group, but differs from its relatives in the broader, decidedly oblanceolate leaflets and the 3-nerved bracts.

UTAH: Uintas, 1869, *S. Watson 241* (type in herb. Columbia Univ.).

Trifolium inaequale

Cespitose glabrous perennial, with very short stems; stipules ovate, short-acuminate, about 1 cm. long; petioles 3–10 cm. long, glabrous; leaflets oblanceolate or oblong, acute or obtuse, minutely denticulate, rather fleshy, 1.5–3 cm. long; peduncles 1–2 dm. long; heads sub-globose; bracts ovate or lanceolate, 5–7 mm. long, usually shorter than the calyces, usually cleft or toothed at the apex; calyx glabrous; tube 3 mm. long; teeth unequal, the upper 2–2.5 mm., the lower 3.5–4 mm. long, lance-subulate; corolla purple, about 1.5 cm. long; ovary 4-ovuled; legume glabrous, stipitate.

This is related to *T. Parryi* and *T. montanense.* From the former, it differs in the decidedly unequal calyx-teeth, the narrower and smaller, ovate instead of obovate, bracts and stipules, and the less sharply denticulate leaflets; from the latter in the larger size and the ovate instead of obovate bracts.

UTAH: Bear River Cañon, 1869, *S. Watson 243* (type in herb. Columbia Univ.); Dyer Mine, Uintah Mountains, 1902, *Goodding 1244.*

Tium variegatum

Perennial with a taproot and short cespitose caudex; stems numerous, strigose, more or less mottled with purplish-brown; stipules triangular or deltoid, 4 mm. long, distinct; leaves 5–8 cm. long; leaflets obovate to nearly orbicular, rounded or retuse at the apex, thick, sparingly strigose, soon glabrate, .5–10 mm. long; peduncles 4–7 cm. long; raceme short, 1–2 cm. long, in fruit 3–6 cm. long, 5–15-flowered; calyx black-hairy; tube 2–2.5 mm. long; teeth subulate, 1–2 mm. long; corolla ochroleucous; banner 6–7 mm. long; wings and keel 5 mm. long; pod scarcely stipitate, about 2 cm. long, 4 mm. broad, oblong, tapering at both ends, slightly arcuate, sulcate on the lower suture except at the ends, acute on the upper suture, mottled with purplish-brown and minutely strigose.

This is perhaps most nearly related to *T. sparsiflorum* (A. Gray) Rydb., but is a much larger and coarser plant. The latter species has usually smaller leaves, smaller corolla, white and tinged with violet, strongly oblique calyx and pods of about half the length, more curved and more distinctly stipitate.

COLORADO: Platte Cañon, May 19, 1894, State Agricultural college, Colorado, distribution *no. 15* (type in herb. N. Y. Bot. Garden).

Hamosa atratiformis

Perennial; stem 2–3 dm. high, erect, branched, strigose; stipules triangular, strigose, 1–2 mm. long; leaves 3–5 cm. long; leaflets 13–19, oblong, strigose below, glabrous above, 4–6 mm. long; peduncles 5–7 cm. long: raceme lax, 2–3 cm. long; calyx black-strigose; tube about 2 mm. long; teeth subulate, 1 mm. long; corolla ochroleucous, about 7 mm. long; pod linear, straight, minutely strigillose.

This is closely related to **H. atrata** (*Astragalus atratus* S. Wats. Bot. King Exp. 69. 1871), but differs in the short leaves and the smaller flowers, which are scarcely more than half as long as in that species.

SOUTHERN UTAH: 1874, *C. C. Parry 47* (type in herb. Columbia Univ.).

Xylophacos aragalloides

Cespitose perennial; stems 1 dm. or less long, decumbent at the base, densely white-strigose; stipules scarious, strigose, triangular, with a subulate acumination, 5–8 mm. long; leaves 10–15 cm. long; leaflets 11–19, lanceolate to elliptic, silky-canescent, 5–12 mm. long, acute; peduncles about 1 dm. long; raceme short, 4–10-flowered; calyx ascending, strigose with black and white hairs; tube cylindric, about 8 mm. long; teeth subulate, 3–4 mm. long; corolla purplish, about 2 cm. long; legume lunate, about 4 cm. long, tapering at both ends, rather deeply sulcate below, transversely reticulate, sparingly strigose; upper suture prominent.

This species is related to *X. amphioxys* (A. Gray) Rydb., but differs in the long subulate instead of triangular calyx-teeth, in the banner much exceeding the wings, and in the narrower leaflets.

UTAH: St. George, 1880, *M. E. Jones 1633* (type in herb. Columbia Univ.); 1877, *Dr. E. Palmer 101.*

Homalobus uniflorus

Pulvinate-cespitose perennial with a much-branched caudex; stipules ovate, scarious, ciliate; leaves reduced to oblanceolate or linear-spatulate phyllodia, appressed silky-canescent, 1–2 cm. long, 1–3 mm. wide; peduncles 1–2 cm. long, usually 1-flowered; calyx silky-canescent; tube campanulate, 2 mm. long; teeth subulate, of about the same length; corolla dark bluish-purple, 8 mm. long.

This species is closely related to *H. simplicifolius* and *H. brachycarpus* Nutt. From the former it differs in the dark bluish-purple, not ochroleucous corolla; the elongated peduncles, the longer and broader leaves, and the comparatively longer calyx-lobes; from *A. brachycarpus* it is distinguished by its solitary flowers and darker corolla.

WYOMING: Evanston, 1897, *Aven Nelson 2971* (type in herb. N. Y. Bot. Gard.).

HOMALOBUS CAMPESTRIS Nutt.; T. & G. Fl. N. Am. **1**: 351. 1838.
Astragalus campestris A. Gray, Proc. Am. Acad. **6**: 229, in part. 1866. Not *Astragalus campestris* L. 1753.
Astragalus convallarius Greene, Erythea **1**: 207. 1893.

There has been a confusion concerning the identity of this species, evidently because Dr. Gray, when he transferred the species to *Astragalus*, had in mind something entirely different from Nuttall's *Homalobus campestris*. All the specimens of this species (except the type and one more) in the herbaria of the New York Botanical Garden and Columbia University have been referred to *H. junceus*. *H. campestris* is also closely related to that species, differing in the black-hairy calyx, the longer calyx-lobes, and the pod, which tapers gradually to the base. The black-hairy calyx and the shape of the pod it has in common with *Homalobus junciformis* (A. Nelson) Rydb., but it has longer calyx-teeth and narrower and longer leaflets. In both *H. junceus* and *H. junciformis* the calyx-teeth are triangular, about as broad as long. All three species have rootstocks, or a deep-set root and the stems branching below ground, the corollas are ochroleucous, the keel curved from near the base and without any purple. What Dr. Gray and many later writers regarded as *Astragalus campestris* is a combination of several species characterized by a cespitose caudex or strongly-branched rootstocks, white, pink- or purple-tinged corollas, and the keel curved only at the tip and with a dark-purple tip. The aggregate consists of *Homalobus decurrens* Rydb., *H. hylophilus* Rydb., *H. tenuifolius* Nutt., *H. divergens* Blankinship (*H. camporum* Rydb.), and other species.

The range of *H. campestris* seems to be limited to Wyoming, northern Colorado and northeastern Utah.

Homalobus oblongifolius

Homolobus hylophilus Rydb. Bull. Agr. Exp. Sta. Colo. **100**: 210, in part. 1906.

Perennial with a cespitose caudex; stems ascending, branched, 2–3 dm. high, glabrous or nearly so; stipules ovate, scarious, 4–5 mm. long; leaves 8–10 cm. long; leaflets 11–19, usually oblong, but varying from elliptic to linear-oblong, 1–2 cm. long, 3–6 mm. wide, glabrous above, sparingly strigose beneath, rounded at the apex; peduncles 5–10 cm. long; raceme short, 3–5 cm. long, 5–10-flowered; bracts lanceolate, scarious, 1 mm. long; calyx strigose with black hairs; tube campanulate, 2–2.5 mm. long; teeth subulate, fully 1 mm. long; corolla 1 cm. long, white, tinged with purple; keel with a narrow dark-purple tip; legumes 2–2.5 cm. long, strigose, 4 mm. wide; the lower suture strongly curved, the upper straight or slightly upturned towards the apex.

This species was included in *H. hylophilus* in my Flora of Colorado, *i. e.*, as far as the Colorado specimens are concerned. It resembles *H. hylophilus*, but the leaflets are thicker and the pod decidedly strigose and of another shape. In *H. hylophilus* the legume is straight and glabrous from the beginning. *H. oblongifolius* is found as far as known only in the mountains of Colorado, while *H. hylophilus* belongs to Montana, northern Wyoming and Idaho.

COLORADO: Cerro Summit, 1901, *Baker 409* (type); Leadville, 1884, *M. E. Jones;* North Park, near Teller, 1884, *C. S. Sheldon 108;* Marshall Pass, *M. E. Jones.*

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JANE COLDEN, AN EARLY NEW YORK BOTANIST

By ANNA MURRAY VAIL

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JANE COLDEN, AN EARLY NEW YORK BOTANIST

By Anna Murray Vail

A few years ago Mr. James Britten published in the *Journal of Botany* (**33** : 12. 1895) a sketch of the life of Miss Jane Colden, with a description of her MS. Flora of New York, which is preserved in the Department of Botany of the British Museum. This sketch was compiled from the numerous, but all too fragmentary, references to Miss Colden that are scattered through her father's correspondence and elsewhere in biographies of the period, and is most entertaining reading.

It is with the object of adding a few more facts to those collected by Mr. Britten, as well as to make known something about the first botanist of her sex in the state, that these notes are offered to the Club.

Jane, the second daughter of Lieutenant-Governor Cadwallader Colden, was born in New York, March 27th, 1724. Her father was the son of the Rev. Alexander Colden, minister of Dunse, in the Merse Berwickshire, Scotland. He received his education at the University of Edinburgh, with a view to entering the Church of Scotland, but, his tastes turning in other directions, he devoted himself to the study of medicine. Owing to limited means, his father was unable to assist him in starting a career at home, so he came to this country in 1710 to try his fortune in America, as he himself puts it in a letter to Kalm. Here he settled in Philadelphia, residing with a widowed sister of his mother's, who had established herself there, and began the practice of his profession. That his affairs did not prosper to his satisfaction or that he had a taste for adventure is evinced by the fact that we hear of him as trading in the colonies and in the West Indies.

In 1715 he returned to England and "in pursuance of the main object, probably, of his visit to his native land," he went to Scotland, where, in November of the same year, he married Alice Christy. The following year saw them both in Philadelphia, and in 1718, accepting the offer from Governor Hunter of a position as master in chancery and surveyor-general, Dr. Colden fixed his residence in New York.

In 1719 a patent for 2,000 acres of land situated in Ulster County was issued to him, and shortly after he procured another thousand acres adjoining the first, and to this manor he gave the name of "Coldengham," still known to-day as Coldenham, in the town of Montgomery, Orange County.*

The details of his active life are too well known to be recounted here. Suffice it to say that about this time Governor Hunter offered him a small stipend for the compilation of a list of the plants and animals of New York. This work was to be pursued on his surveys, but, owing to extensive cutting down of expenditures in the province, it was not carried out. As regards the flora of the state as a whole, this was only accomplished nearly a hundred years later with the publication in 1814 by Jacob Green of his "Catalogue of the Plants Indigenous to the State of New York," and later by the more complete and detailed works of John Torrey, published 1840–43.

In 1728 Dr. Colden with his wife and six young children removed to Coldengham, being led thereto among other reasons "to secure in the — then wilderness abode that leisure for philosophical study to which he was so much inclined."

It was during his residence there for more than thirty years that he maintained a most voluminous correspondence with a number of learned men in Europe. In the intervals of political and literary pursuits he devoted himself to the reclamation and cultivation of his estate, and, with his accomplished wife, to the education of their children. It was here that he wrote that first of "local floras" of New York, the "Plantae Coldenghamiae," eventually published by Linnaeus, with whom he had been in

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* Purple, E. R. Genealogical Notes of the Colden Family in America. New York; privately printed, 1873.

Cadwallader Colden

[From the Historical Magazine, volume 9, January, 1865.]

correspondence, in the "Acta Societatis Regiae Scientiarum Upsaliensis," in 1749, and here Jane grew up and acquired that taste for natural history of which her father wrote in the oft-quoted letter to Gronovius. The portions of this letter which refer to Jane are here printed as copied from the original draft:*

"To DR. JOHN FREDERIC GRONOVIUS
Senateur de la Ville de Leiden.
New York Oct. 1st, 1755.

* * * "I (often) thought that Botany is an amusement which may be made greater to the Ladies who are often at a loss to fill up their time (& that) it could be made agreable to them (it would prevent their employing so much of their time in trifling amusements as they do). Their natural curiosity & the pleasure they take in the beauty & variety of dress seems to fit them for it (far more than men). The chief reason that few or none of them have hitherto applied themselves to this study I believe is because all the books of any value are wrote in Latin & so filed with technical words that the obtaining the necessary previous knowledge is (attended with) so (much) tiresome and disagreable that they are discouraged at the first set out & give it over before they can receive any pleasure in the pursuit.

"I have a daughter, who has an (natural) inclination to reading & a curiosity for natural philosophy or natural History, & a sufficient capacity for attaining a competent knowledge. I took the pains to explain Linnaeus's System (for her), and to put it in English for her use by freeing it from the Technical terms, which was easily done by useing two or three words in place of one. She has now grown very fond of the study, and has made such progress in it that as I believe would please you if you saw her performance, tho' perhaps she could not have been persuaded to learn the terms at first, she now understands in some degree Linnaeus' characters, notwithstanding that she does not understand Latin. She has already a pretty large volume in writing of the Description of plants. She was shown a method of taking the impression of the leaves on paper with printers ink, by a simple kind of rolling press which is of use in distinguishing the species by their leaves. No description in words alone can give so clear an idea as when the description is assisted with a picture. She has the impression of 300 plants in the manner you'l see by the sample sent you. That you may have some conception of her manner of describing (of plants) I propose to enclose some (two or three) Samples in her own writing, some of which I think are new genus's. One is of the *Panax folys ternis ternatis* in the Flora Virg. . . . I never had seen the fruit of it till she discover'd it. The fruit is ripe in the beginning of June and the plant dies immediately after the fruit is ripe & no longer to be seen. Two more I have not found described any where and in the others you will find some things particular which I think are not taken notice of by any Author I have seen. If you think S^{r} that She can be of any use to you She will be extremely pleased in being employed by you either in sending Descriptions for any Seeds you shall desire or dried specimens of any particular plants that you shall mention to me. She has time to apply herself to gratify your curiosity more than I ever had and now when I have time the infirmities of age disable me."

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* Colden MSS. in the New York Historical Society. For permission to examine some of these MSS. I am indebted to the librarian of the New York Historical Society.

This letter is somewhat differently printed in "Selections from the Scientific Correspondence of Cadwallader Colden with Gronovius, Linnaeus, Collinson and other Naturalists," Am. Jour. Sci. and Arts 44: 133. 1843.

Mr. Britten describes the "pretty large volume in writing" as follows:

"The 'pretty large volume in writing' is now in the Department of Botany in the British Museum. After the writer's death it passed into the hands of F. von Wangenheim, then into those of Godfrey Baldinger, and finally became the property of Banks. An account of the MS. is prefixed by Wangenheim, and a title-page was added by Baldinger, of which the following is a transcript:

FLORA
NOV.-EBORACENSIS.

Plantas in Solo Natali
collegit, descripsit,
delineavit,
COLDENIA,
CADWALLADER COLDENS
Filia.

Divitiis Bibliothecae
Josephi Banks
adiecit

Ern. Godofr. Baldinger,
olim in Aca. Jememsi Prof. Bot.
et Med. Theoret.; in Acad. Goettingensi
Med. Pract.; in Academia Marburgensi
Ord. Medicor. Prof. Primarius.

Anno 1801

"The prefatory note by Wangenheim is published in the account of the MS. given in Schrader's *Journal für die Botanik* for 1800 (Göttingen, 1801) p. 468. The following is a translation:

'This MS., which has never been printed, contains a part of the New York Flora, and has been composed by a lady, the daughter of Governor Cadwallader Colden, well known for his botanical works, and also a physician. This lady married a doctor of medicine, Farquer (Farquhar), a Scotchman by birth, and she died soon afterwards. Some of the names are according to her father and according to Gronovius, and some are according to the Brandenburg doctor Schoepff, who has read this work. The trivial names are according to Linnaeus.

'This work is a remarkable one because it is that of a lady who possessed such a love for botany that she learned Latin, and judging by its nature is so worthy and correct that it contains many even minute things.

'This is written by F. von Wangenheim,
Captain in the Field-Jäger Corps of the Landgrave of Hesse
New York, May, 1782.'

"It will be observed that this narrative contradicts Gray's statement that Jane Colden died unmarried: Pritzel accepts Schrader's account but adds, 'Moriens (1754) Floram manuscriptam Novi Eboraci tabulis ornatam reliquit Wangenheimio.' If the MS. was bequeathed to Wangenheim, it is strange that he did not say so: the date given for her death is certainly inaccurate. Wangenheim's statement that she 'learned Latin' is contrary to her father's account, but probably only means that she acquired the Latin names of the plants she described; the descriptions in the MS. (to which she gave no title) are all in English.

"The actual number of figures is 340: the numbers of the descriptions run to 341, but these are really less numerous, as a good many pages are blank, save for the name of the plant at their head. This suggests that the figures were made before the descriptions ; they are very poor and consist only of leaves.* The descriptions, on the other hand, are excellent — full, careful, and evidently taken from the living specimens. One of these has been published in full (No. 153 of the MS.) in *Essays and Observations*, vol. ii. (Edinburgh, 1770). The plant (*Hypericum virginicum*) to which it refers had been sent her by Alexander Garden, who found it at New York in 1754; in return, Miss Colden sent him the description of the same plant, which she had discovered during the previous summer, and, 'using the privilege of a first discoverer, she was pleased to call this new plant *Gardenia*, in compliment to Dr. Garden.' Another of her descriptions, translated into Latin, was sent by Ellis to Linnaeus in 1758, and is published in the *Correspondence of Linnaeus* i. 94. The plant to which it referred was retained by Linnaeus in *Helleborus*, but separated by Salisbury (who has been followed by subsequent botanists) under the name of *Coptis*. Miss Colden (No. 292) called it *Fibraurea*, a translation of the popular name 'Gold Thread.' Ellis, forwarding the description, says : 'This young lady merits your esteem, and does honour to your System. She has drawn and described 400 plants in your method only : she uses English terms. Her father has a plant called after him *Coldenia*, suppose you should call this *Coldenella*, or any other name that might distinguish her among your Genera.' Unfortunately, Linnaeus did not recognize the genus as distinct, so neither of these names was adopted."

" Little indications in the descriptions show that Miss Colden went among the country folk and noted their names and rustic remedies. Thus of *Pedicularis tuberosa* (No. 41) she says : 'The Pedicularis is called by the country people Betony : They make Thee of the Leaves, and use it for the Fever and Ague.' *Asclepias tuberosa* is 'an excellent cure for the Colick. This was learn'd from a Canada Indian, and is called in New England Canada Root. The Excellency of this Root for the Colick is confirm'd by Dr. Pater of New England, and Dr. Brooks of

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* The figures are merely ink outlines washed in with neutral ink, not the 'nature printed' ones mentioned in Colden's letter, of which, however, there is one example at the end of the book.

Maryland likewise confirmed this.' The root of *Solidago canadensis* 'is used in Carolina for the cure of the Negro Poison'; *Oenothera biennis* is 'call'd here by the Country People, Seabedge'; *Malva caroliniana* is 'called in South Carolina, Bohea Tea:' and *Gillenia trifoliata* is 'call'd here, Ipecacuanha.' Occasionally a note shows particular observations, such as this on *Clematis virginiana*: 'Neither Linnaeus take notice (*sic*) that there are some Plants of the Clematis that bear only Male flowers, but this I have observed with such care, that there can be no doubt of it.'"

Numerous references to her in Darlington's[*] Memorials of John Bartram and Humphry Marshall, Smith's[†] Correspondence of Linnaeus and elsewhere in contemporaneous records and biographies, evince the fact that she had become well known to her father's friends and that her botanical accomplishments were appreciated and her services in the matter of the collection of seeds and plants often taken advantage of.

Peter Kalm on the 29th September, 1748, sends his respects to Mistress Colden, the Misses and young Master Colden.

In a letter from John Bartram[‡] to Peter Collinson dated 1753, he describes a journey to the "Katskill Mountains" with his son "Billy" and writes of a visit to Coldengham in the following words:

> "At night, we lodged seven or eight of us (they being two families) in the hut, hardly big enough for a hen-roost — I and Billy on the ground — after a piece of a musty supper. Slept but little in this lousy hut, which we left, as soon as we could well see our path, in the morning, having paid him half a crown, which he charged, and reached Dr. Colden's by noon. Got our dinner, and set out to gather seeds, and did not get back till two hours within night; then looked over some of the Doctor's daughter's botanical, curious observations. Next morning, as soon as I could see, we hunted plants till breakfast: then the Doctor's son went with me to Doctor Jones's, where we observed the Pines, on a high hill near the Doctor's. After dinner, we went to the river to gather *Arbor Vitae* seeds: then returned to Dr. Colden's by two hours within night. In the morning gathered seeds till break-

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[*] Darlington, W. Memorials of John Bartram and Humphry Marshall. Philadelphia. 1849.

[†] Smith, T. E. Selection of the Correspondence of Linnaeus. London. 1821.

[‡] Darlington. Memorials, 195.

fast. These two days I could have refreshed myself finely, if the Doctor had been at home, or durst have eaten freely of what was set before me: for they all were very kind."

Further on in a letter from Peter Collinson to John Bartram dated January, 1756, he expresses himself in regard to Miss Colden's accomplishments in the following terms:

"Our friend Colden's* daughter has, in a scientific manner sent over several sheets of plants, very curiously anatomized after his† method. I believe she is the first lady that has attempted anything of this nature. They are to be sent to Dr. Gronovius; and he, poor man! I believe is in a bad state of health; for I cannot get a line from him (who used to be very punctual), if he has received Billy's fine drawings of Oaks, and thy system. Though I have writ several letters, I shall this day send another."

But the most interesting of all is the letter from John Bartram to Miss Jane Colden dated January 24th, 1757, that begins:

JOHN BARTRAM TO MISS JANE COLDEN.‡

"January the 24th, 1757.

"RESPECTED FRIEND JANE COLDEN:

"I received thine of October 26th, 1756, and read it several times with agreeable satisfaction: indeed, I am very careful of it, and it keeps company with the choicest correspondence, — European letters.

"The Viney plant thee so well describes, I take to be the *Dioscorea* of Hill and Gronovius; though I never searched the characters of the flower so curiously as I find thee hath done; but pray search them books, thee may presently find that article.

"I shall be extremely glad to see thee once at my house, and to show thee my garden. My Billy is gone from me to learn to be a merchant, in Philadelphia, and I hope a choice good place, too (Captain Childs). I showed him thy letter, and he was so well pleased with it, that he presently made a packet of very fine drawings for thee, far beyond Catesby's, took them to town, and told me he would send them very soon. I was then in a poor state of health: but am now well recovered. We very gratefully receive thy kind remembrance, and my two dear friends, thy father and mother. I want once more to climb the Katskills; but I think it is not safe to venture these troublesome times.

"I have had several kinds of the *Cochleata*, or Snail Trefoil, and *Trigonella*, or Fenugreek; but, being annual plants, they are gone off. The species of Persicary thee mentions, is what Tournefort brought from the three churches, at the foot of Mount Ararat.

"The *Amorpha* is a beautiful flower; but whether won't your cold winters kill it?

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* Darlington. Memorials, 202.

† Linnaeus.

‡ Darlington. Memorials, 400.

"If the Rhubarb from London be the Siberian, I have it. I had the Perennial Flax, from Livonia. It growed four feet high, and I don't know but fifty stalks to the root; but the flax was very rotten and coarse. The flowers are large and blue. It lived many years and then died.

JOHN BARTRAM.

In a letter written to Dr. Colden,* Dr. Alexander Garden of Charleston, S. C., writes in 1754 "I shall be glad to hear of Miss Colden's improvements, which no doubt increase every day, and may we again be surprised with more than a *Dacier*, even in America."

Dr. Garden's letters, both published and unpublished, contain many allusions to Jane and there were evidently frequent communications that passed between them. In 1755 in a letter to Mr. Ellis † he writes of Dr. Colden as a great botanist and adds with true eighteenth century gallantry that "his lovely daughter is greatly master of the Linnean method." This last statement in regard to her personal appearance, if she at all resembled her distinguished, but homely father, being more due to the adulatory style of the day than to actual fact, and that Jane's good sense resented an excess of flattery is shown in some later letters.

In an undated and unlabeled fragment addressed presumably to Dr. Colden ‡ he writes:

"I have sent you some of the Amorpha a very Curious plant & peculiar to Carolina — in Linnaeus Species Plantar. there is only one Species known but I have (another) which I have brought down from Saluda with me — Miss Colden will be much pleased with it. It flowers with us in Aprile, May & June, & its flowers make a beautiful apearance in a spike. When you favor me with a line please direct to Dr. Alex^{d}. Garden, Physician in Charlestown, So. Carolina."

Again in a letter dated Charlestown Febry 18, 1755, he writes:

"I sent you some more of the true Indigo seed and some Millet Seed which I am persuaded will both grow very well to you. I mentioned to Miss Colden that the Small Bags of Shells something like Hops that she has are the real Matrices of the Buccinum ampullatum of Dr. Lister — Give me leave to present my Compliments to Miss Colden and your kind family."

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* Gray. Selections.

† Smith. Correspondence of Linnaeus, 348.

‡ Colden MSS.

On May 20th, 1755, he writes:

"It gives me great pleasure that you give me leave to send Miss Colden's Description of that new plant to any of my Correspondents as I had before sent it to Dr. Whytt at Edinburgh — By your second letter I find I have very innocently offended Both you and Miss Colden by some of the expressions that insensibly dropt from my pen as archetypes of what my heart dictated in warm sincerety. This gives me real concern and give me leave to assure you I shall endeavour as far as in my power to amend anything in my conduct or manner of writing that you are kind enough to point out as wrong. I trust that Both you and your Daughter will forgive me for once. I shall be more sparing in saying what y. think is due to such merit in the future. The Expression which you say gave her most offence, gives me now a great deal of uneasiness as I suspect it has deprived me of the pleasure of a letter from her by last opportunity — It is now past the season of Seeds but I'll endeavour to procure Such as Miss Colden may want this year, tho' my present Business confines me much to Town. — Please offer my compliments to Miss Colden & Family."

Another letter and one of the last containing references to Miss Colden is the following:

Charlestown, November 27, 1755.

"Sir — Your most obliging fav^{r} of Octo^{re} last now lyes before me, which came very safe to hand by Schermerhorn as Did the Papers of seeds which your daughter was kind enough to honour me so by his formal trip. I readily confess my neglect in not writing her in return sooner but an affair of Love quite engrossed my thoughts for a season * — [and he ends a long somewhat fantastic letter with —] offer of a kindest compliment to Miss Colden," etc.

Miss Colden's accomplishments were not all, however, of a botanical nature. Her mother, Mrs. Colden, the daughter of a Scotch minister, is said to have been a distinguished woman and fully able to fill the social position and to discharge the many duties that fell to her lot. In addition to the numerous cares that were imposed on the housewife of the period, Mrs. Colden assisted her husband in the administration of his estate and in the copying of his correspondence, and owing to his political duties and consequent lengthy and frequent absence from home, much of the education of their children must have devolved on her. She is said to have taught them habits of "virtue and

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* The "affair of love" is doubtless an allusion to his approaching marriage, which occurred in Charleston on Christmas Eve, 1755.

economy" and gave them in her life and character the "brightest of examples," so it can be presumed that her daughters were apt scholars in the accomplishments required of well-bred and trained gentlewomen of the day.

The following reference to Miss Colden was the means of identifying with a fair amount of certainty some unsigned household records of hers that are preserved among her father's scientific papers.

Walter Rutherfurd was an ancestor of the well-known New York family of that name. He came to America in 1756, while the French war was in progress, and served as an officer of the Royal Americans. In New York in 1758 he married Catharine, the widow of Elisha Parker and a daughter of James Alexander. About this time he wrote to a friend in Scotland, describing a visit to Albany : †

> " At one of our landings we made an excursion to Coldenham, the abode of the venerable Philosopher Colden, as gay and facetious in his conversation as serious and solid in his writings. From the middle of the Woods this family corresponds with all the learned Societies in Europe. Himself on the principles of Matter and Motion, his son on Electricity and Experiments. He has made several useful discoveries and is a tolerable proficient in music. His daughter Jennie is a Florist and Botanist, she has discovered a great number of Plants never before described and has given their Properties and Virtues, many of which are found useful in Medicine, and she draws and colors them with great beauty. Dr. Whyte, of Edinburg, is in the number of her correspondents. N. B. She makes the best cheese I ever ate in America."

With this note in mind it does not seem unreasonable to suppose that the " Memorandum of Cheese made in 1756" is in Jane's writing. This " Memorandum " consists of five sheets of foolscap and is the careful and painstaking record of her year of cheesemaking. The following are the two first receipts :

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* Colden MSS.

†Family Records and Events, Compiled chiefly from the original MSS. in the Rutherfurd Collection. By Livingston Rutherfurd. Privately printed ; 1894. (Only 150 copies.)

MEMORANDUM OF CHEESE MADE IN 1756.

May

25 No 1. To this I had a large Pan of Milk more than the Cheese tray would hold. I had used Rennet that was left since last summer, it was very long of thickening & I was obliged to put a great deal in. I made it according to a receipt I got from Sister Willett.* In scalding the Curd after it was chopped there was a good deal of yellow oyl raised on top of the Whey, as it was on the Curd & and when I drained it the second time it had lost much in Bulk. I can not approve of this method, it lost a good deal of rich whey. I expect it will be strong of the Rennet and not be good.

(It was good except a little too much taste of the Rennet)

27 2. To this I had the same quantity of milk as to the former, I put one Spoonfilles of the Rennet in it, it thickened in a very short time. I made it after my Mother's old manner, it was a tender good curd and lost very little rich Whey. When it came out of the press it weighed 25 pounds. The first weighed 20 pounds, the third day after it came out of the press.

Later, in the following November she weighed her cheeses and notes their reduced bulk, and there are also notes as to how they eventually tasted. At the end of the sheets she made a list of her milkings and the sales of her butter, showing that in the year she sold 348 pounds of butter that netted her £12.13.3. She even did not omit the names of the purchasers of her butter, nor the amounts sold each time.

It is impossible not to conjecture as to whether any of these cheeses were those extolled by Walter Rutherfurd! And it is much to be regretted that the drawings "coloured with great beauty" have all disappeared. They surely cannot have been the figures done in "ink outlines washed in with neutral ink" of the "pretty large volume" so graphically described by Mr. Britten.

Jane Colden † married Dr. William Farquhar, a Scotchman and a widower; their marriage license was dated March 12th, 1759. She died March 10th, 1766; her only child in the same year and her husband in 1787. He is described as "a very worthy good Scotsman" and for some years before the Revolutionary War one of the chief and fashionable practitioners of medicine, "distinguished for his abilities and knowledge" in New York City and vicinity. He was one of the founders of the St. Andrew's Society of the State of New York, formed in 1756 of Scotchmen by birth or descent for social and charitable purposes. He acted as an "assistant" (manager) of the Society in 1756 and as vice-president in 1757.*

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* Alice, third daughter of Governor Colden, born September 27, 1725, married Colonel William Willett, she being his second wife. She died in 1762.

† Purple, Colden Family in America, 20.

After 1759 Jane's name does not appear to be mentioned in her father's correspondence, nor can any reference to her marriage be found there. Her place of burial is unknown.

Governor Colden died on Long Island, September 20, 1776, aged over eighty-eight years, and was buried in the private burying-ground on the Willett farm, "Spring Hill," that he purchased in 1762 and where he spent the last years of his life. This property had been deeded by the governor before his death to his son David, but owing to the latter's loyalty to the Crown it was confiscated in 1779 and passed into other hands. At the present time, Governor Colden's farm lies within the limits of Cedar Grove Cemetery in the Borough of Queens, and the ancient burying-place is still extant. Though fallen into decay, it has not been disturbed and is to be preserved in its present condition. Numerous rough stones, bearing the names of members of the Willett family are dated from 1722 to 1797, and local authorities relate that there is a stone with a Colden name on it there, but owing to the heavy snowdrifts at the time of writing, this could not be verified, and does not agree with descriptions of the spot made in 1873.† Governor Colden's fine old mansion is now the office of the cemetery, and is said to have been but little altered in recent years.

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* For some of these details, I am indebted to Mr. George Austin Morrison Jr., Secretary of the Saint Andrew's Society.

† Purple, Genealogical Notes, 9.

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Vol. 22, part 2, issued December 18, 1905, contains descriptions of the families Saxifragaceae and Hydrangeaceae by Dr. J. K. Small and Dr. P. A. Rydberg; the Cunoniaceae, Iteaceae and Hamamelidaceae by Dr. N. L. Britton; the Pterostemonaceae by Dr. J. K. Small; the Altingiaceae by Percy Wilson and the Phyllonomaceae by Dr. H. H. Rusby.

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TWO NEW SPECIES OF AYTONIA FROM JAMAICA

BY CAROLINE COVENTRY HAYNES

NEW YORK
1907

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 57–60, *pl. 5, 6.* 1907]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 57–60, *pl. 5–6*. 1907]

Two new sPecies of Aytonia from Jamaica

CAROLINE COVENTRY HAYNES

(WITH PLATES 5 AND 6)

Aytonia Evansii sp. nov.

Thallus light-green, with a narrow purple margin, plane, ovate to linear-oblong, lingulate, 10–14 mm. × 4–7 mm., innovating from apex or laterally from costa, or dichotomous; margins of thallus elevated, undulate, crisped; width of thallus in cross-section eight times that of maximum height; the epidermal cells somewhat quadrate with distinct trigones, cuticle finely granulate; the stomata small, not elevated above thallus, 4 or 5 cells around the pore in 1 or 2 concentric series; ventral scales vinous-purple, imbricated, scarcely decurrent, lunate or obliquely ovate, reaching beyond thallus and reflexed only at notched apex, well-developed and persistent, however, from base of thallus to apex, tapering gradually to a long lanceolate occasionally geminate point, margins entire: oil-bodies completely filling isolated cells occurring generally through the thallus excepting in epidermal layer: monoicous: ♀ receptacles usually several in a series: androecium situated directly behind ♀ receptacle, furcate, surrounded with purple lanceolate or linear paleae 2–7 cells in maximum width: peduncle 5 mm. long: carpocephalum 2–3-lobed, generally maturing two opposite sporogonia, concave at apex, scales of the carpocephalum lanceolate or linear-lanceolate, 5–12 cells in maximum width, nearly hyaline: spores averaging 87 μ, yellow or brownish, enveloped in a very loose reticulate-rugose exospore: elaters 2–4-spiral, attenuate at ends 223–306 μ in length, 13 μ in maximum width. (PLATE 5.)

The above description has been drawn from material collected on banks, near Portland Gap, Blue Mountains, Jamaica, July 21, 1903, *A. W. Evans 213*.

Plagiochasma elongatum Lindenb. & G., from Mexico, known to the writer only through descriptions, appears to resemble the Jamaican plant but the latter differs in possessing a shorter and broader frond which is 10–14 mm. long while that of *P. elongatum* reaches 35 mm.; *P. elongatum* has only 2–3 cells around pore, the Jamaican plant 4–5 cells; the ventral scales of *Aytonia Evansii* taper gradually, while those of *Plagiochasma elongatum* are described by Stephani * as abruptly attenuate to the appendiculum.

Aytonia jamaicensis sp. nov.

Thallus light-green with a narrow purple margin, somewhat plane or broadly canaliculate, ovate to linear-oblong, 5–18 mm. × 5–6 mm., innovating from the apex and from the side of the costa; margins of thallus elevated undulate-crenulate and slightly crisped; width of thallus in cross-section six times that of maximum height; the epidermal cells generally quadrate, showing small trigones; the stomata large, elevated, with 5–8 cells around the pore in 2–4 concentric series: ventral scales vinous-purple, strongly decurrent and approximate in the median ventral line, imbricated, broadly lunate or ovate, projecting beyond margin of thallus only at notched apex, reflexed over the growing point; appendicula ovate-lanceolate, occasionally geminate, strongly constricted, 7–12 cells in maximum width, with a uniseriate apiculum of 1–3 cells in length, margins subentire, undulate-crenate or sparingly toothed: oil-bodies completely filling isolated cells in the colorless stratum of thallus: monoicous: ♀ receptacles usually several in a series on an apical innovation in front of androecium: scales of androecium deltoid or cuneate-ovate: peduncle 11–16 mm. long: carpocephalum 2–4-lobed, generally maturing two opposite sporogonia and then concave or transversely furrowed above or sometimes slightly convex; scales of the carpocephalum lanceolate or linear-lanceolate, 5–14 cells in greatest width, often acuminate with a constriction near the apex: spores averaging 85 μ, yellow or brownish, enveloped in a very loose reticulate-rugose exospore, this easily detachable, spore after removal of exospore averaging 46 μ: elaters 2–3-spiral, occasionally forked, somewhat attenuate at ends, 255–374 μ long, 8 μ in maximum width. (PLATE 6.)

The above description has been drawn from material collected at Chestervale, Jamaica, February, 1903, *L. M. Underwood 1173* (type) and *1177* [both mixed with *Reboulia hemisphaerica*].

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* FRANZ STEPHANI. Species Hepaticarum. Bulletin de l'Herbier Boissier **6**: 785. 1898.

The species is related to *Plagiochasma Wrightii* Sulliv., which shows the following differing characteristics: stomata not so much elevated, the 5–8 cells around the pore being in 2 or 3 concentric series; appendicula not so much constricted, narrower, margins always entire; peduncle shorter, 2–4 mm. (?); scales of the carpocephalum never constricted; spore distinctly tetrahedral and winged, exospore not so loose. Type duplicate of *P. Wrightii* from Texas in Herbarium Underwood shows 5–8 cells around pore instead of 6 cells as given by Herr Stephani in his *Species Hepaticarum.*

These two Jamaican species differ from each other in shape and size of stomata, form of ventral scales and their appendicula, the position of androecium and in the character of the cuticle.

The above work was done under the supervision of Dr. Marshall A. Howe to whom I am deeply grateful. Thanks are also due Professors Underwood and Evans for allowing me to study their material.

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Explanation of plates 5 and 6

PLATE 5. *Aytonia Evansii* sp. nov.

1 and 2. Plant, natural size.
3. Outline of cross-section of thallus, × 9.
4. Median cross-section of thallus showing stomata, × 55.
5. Stoma, × 242.
6. Plant, showing two immature carpocephala and androecium, × 6.
7. Plant, showing nearly mature carpocephalum, with peduncle 4 mm. long, and androecium, × 6.
8 and 9. Ventral scales, × 13.
10. Ventral scale showing geminate appendicula, × 13.
11–13. Scales from the carpocephalum, × 13.
14. Scale from the carpocephalum showing cells, × 55.
15. Surface view of stoma; epidermal cells and trigones, × 360.
16. Spore, inner face, × 250.
17. Spore, outer face, × 250.
18. Spore, optical section, × 242.
19. Elater, 3-spiral, × 175.
20. Elater, 2-spiral, × 175.
21. Oil-body completely filling cell, × 250.
22. Scale from androecium, × 55.

PLATE 6. *Aytonia jamaicensis* sp. nov.

1. Plant, natural size.

2 and 3. Outlines of cross-sections of thallus, × 9.

4. Median cross-section of thallus showing stoma, × 55. The fungal hyphae shown here in certain cells were found inalmost all specimens examined and occur generally through the ventral portions of the thallus.

5. Stoma, × 242.

6 and 7. Upper and lower sides of a single immature carpocephalum, × 6.

8 and 9. Opposite sides of a single carpocephalum with two mature sporogonia no. 8 showing upper portion of peduncle, × 6.

10 and 11. Opposite sides of a single carpocephalum showing the mature sporogonia, a third abortive one, and upper portion of peduncle, × 6.

12. Ventral scale showing geminate appendicula, × 17.

13. Ventral scale showing single appendiculum, × 17.

14–17. Scales from the carpocephalum, × 13.

18 and 19. Scales from the carpocephalum showing cells, × 55.

20. Surface view of stoma, × 360.

21. Surface view of epidermal cell and trigones, × 250.

22. Spore, inner face, × 250.

23. Spore, outer face, × 250.

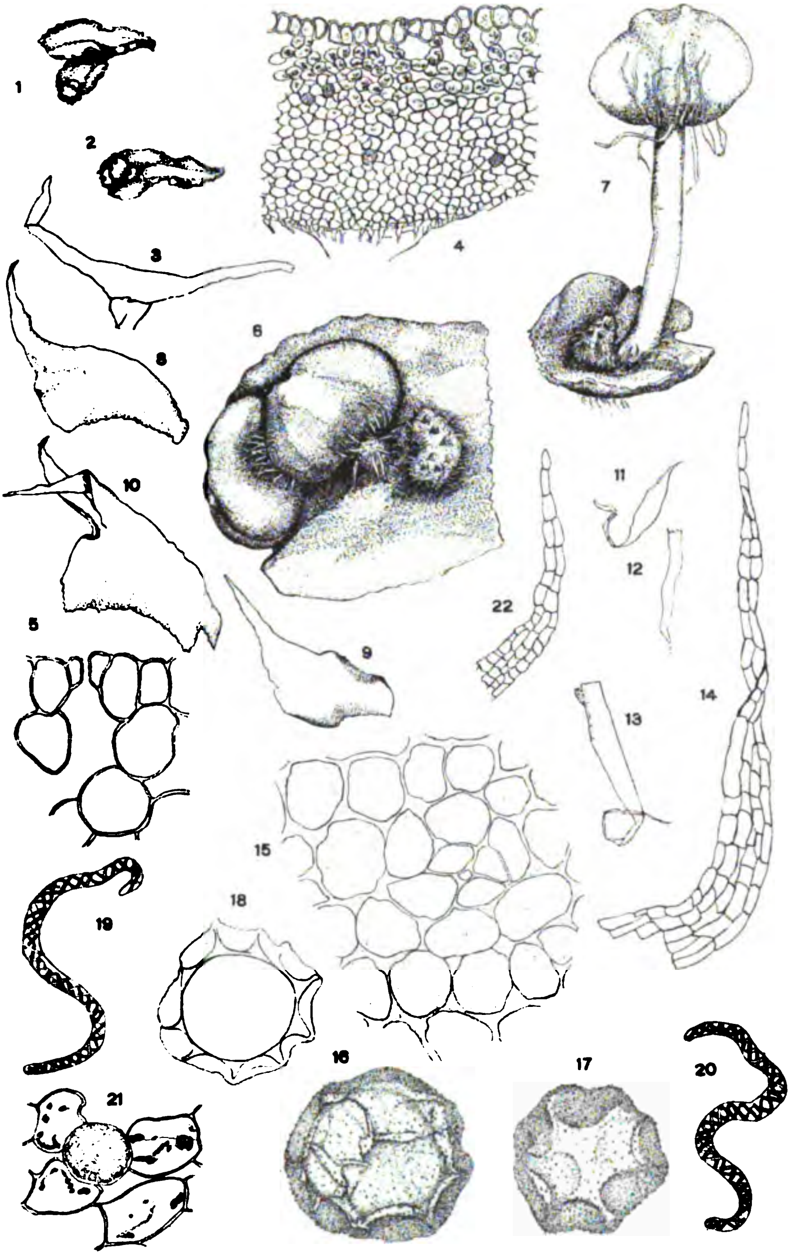
24. Spore, optical section, × 242.

25. Elater, 2-spiral, × 182.

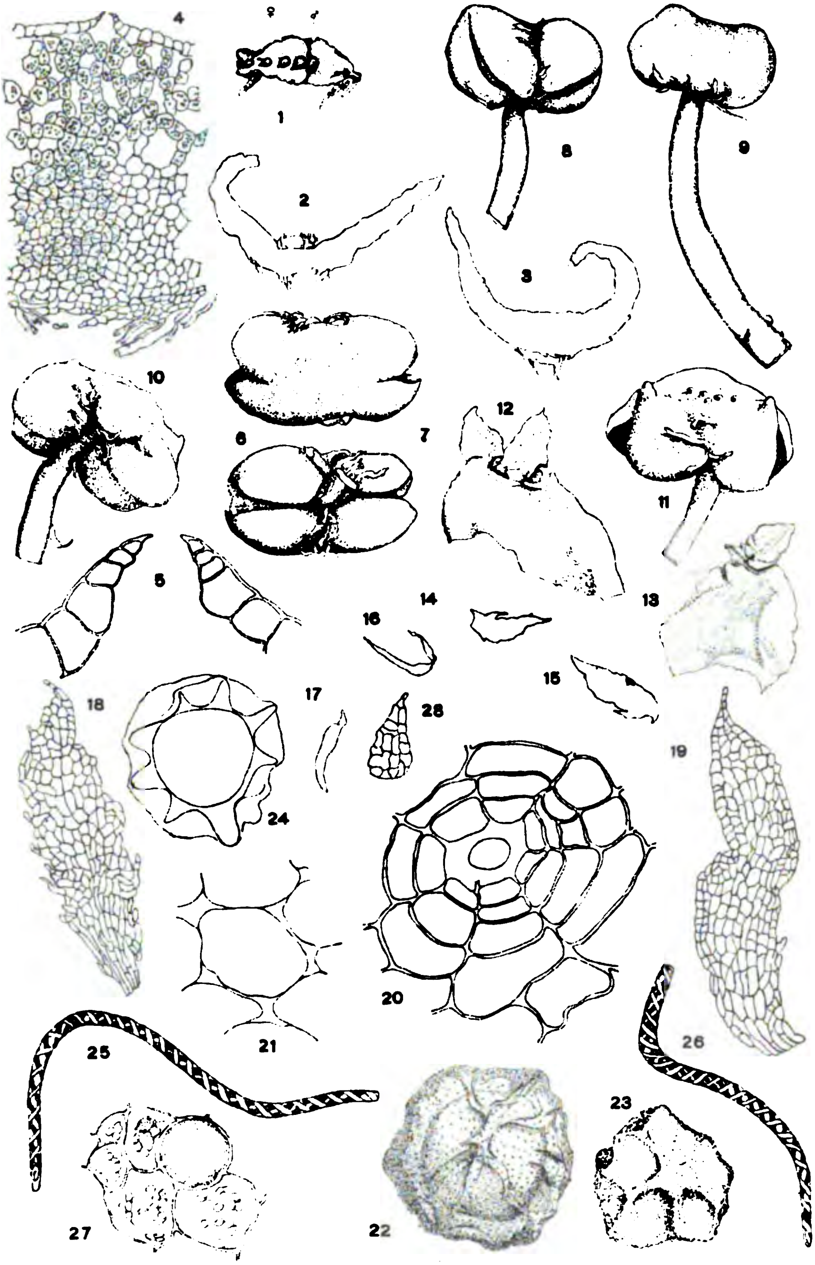
26. Elater, 3-spiral, × 175.

27. Oil-body completely filling cell, × 250.

28. Scale from androecium, × 55.



AYTONIA EVANSII Haynes.



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STUDIES IN NORTH AMERICAN PERONOSPORALES—I. THE GENUS ALBUGO

BY GUY WEST WILSON

NEW YORK
1907

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 61-84. 1907]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 34: 61-84 1907.

Studies in North American Peronosporales — I. The genus Albugo

GUY WEST WILSON

The North American species of *Peronosporales* offer a rich field for investigation. Containing as this order does some of the worst fungous pests of the farm and garden, extensive studies of certain species were undertaken at an early date in our mycological history, yet our present knowledge of the group is very fragmentary. The greater part of the printed information concerning it consists of notes on various species scattered through articles of a general mycological nature. Some species have been made the subject of independent articles, while few papers deal with a considerable number of species. Only two of these are comprehensive in scope. One is a series of notes by Swingle * upon the specimens in the herbarium of the Division of Vegetable Pathology, the other is Dr. Farlow's monograph,† which includes thirty-eight species and requires less than an octavo page for a complete host index. Since then the number of species credited to North America has almost doubled and the list of hosts increased many fold.

The genus *Albugo* constitutes the family *Albuginaceae*, the species of which bear a superficial resemblance to the *Uredinales*, from which they are readily distinguished by the light color and glistening appearance of the sorus and by the unsculptured conidia which are borne in chains. More marked points of difference, but not so readily observed, are the germination of all spores by zoöspores instead of by germ-tubes, and the production of sexual oöspores.

The oöspores of all the North American species have been studied, in the preparation of the present paper. Upon the basis of oöspore-characters the species fall into two well-defined groups. The first of these includes the North American *A. candida*, *A. Ipomoeae-panduranae* and *A. Lepigoni*, and the foreign *A. sibirica* and *A. tropica*. This group is characterized by having the epispore of the oöspore tuberculate or ridged. According to the investigations of Zalewski * and Stevens † this is the more specialized group. The former author points out the more complex character and apparently more complete development of the epispore, while the latter deals with cytological phenomena only. The second group of species is characterized by a reticulate epispore and contains the remaining species of which the oöspores are known, and in all probability the two species in which they are at present unknown. There are three or four well-defined types of reticulation represented, all of which are found among the American species. The first of these is represented by *A. Bliti* and *A. platensis* and may be considered typical of this group. The reticulations are very evident, the meshes large and the areolae deep and unoccupied by any elevations. The pattern is often somewhat imperfectly developed. From this type the other species vary in a striking manner, yet the primary characters remain the same. In *A. Tragopogonis* and *A. Swertiae* the areolae are not so deep and the reticulations are crested at their angles with more or less prominent tubercles. In *A. Portulacae* the variation takes the form of tubercles within the areolae while the reticulations themselves are similar to those of *A. Bliti.* Unique within the genus is *A. occidentalis*, which has the epispore finely reticulate and the areolae so shallow as to give the impression, at first sight, of pits rather than reticulations. The conidia are quite similar to those of *A. tropica*, but the oöspore-characters indicate a closer relationship to *A. platensis* or *A. Swertiae.* According to Zalewski the reticulate spores have a less perfectly developed epispore which reaches its highest development in *A. Tragopogonis.* This arrangement of species is confirmed by the work of Stevens.

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* Jour. Myc. 7: 109–130. 1892.

† Bot. Gaz. 8: 306–325, 327–337; 9: 37–40. 1883–84.

The material upon which the present paper is based is contained in the herbaria of the New York Botanical Garden and of Columbia University and in the private collections of Dr. L. M. Underwood, Dr. J. C. Arthur and the author. The literature of the genus has been carefully looked over by means of Dr. Farlow's Bibliographical Index and other aids. No localities are cited from which material has not been examined, but all published reports have been taken into account in determining the distribution of species; and mention is made of all reported hosts upon which no specimens have been seen. The determinations of all hosts have been verified, with the resulting omission of a few of those previously published. These discrepancies are noted in the proper places by the insertion after the specimen of the previously published host name. All specimens containing oöspores are marked by an asterisk (*). Inasmuch as the hosts, or species closely related to the hosts, of all the extralimital species of the genus occur in North America, these species have been included in the key, and brief mention made of them in their place in the sequence of species. In conclusion I wish to express my appreciation of the courtesies which have been shown me in this work by the loan of specimens, by critical suggestions and by the determination of hosts.

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* Bot. Cent. 15: 215–224. 1883.

† Bot. Gaz. 32: 77–98, 157–169, 238–261. *pl. 1–4 + text figs.* 1901.

ALBUGO (Pers.) S. F. Gray, Nat. Arr. Brit. Pl. 1: 540. 1821

Uredo § *Albugo* Pers. Syn. Meth. Fung. 223. 1801.
Cystopus Lév. Ann. Sci. Nat. III. 8: 371. 1847.

Conidiophores simple, cylindric or clavate, crowded into subepidermal sori without peridium or paraphyses; conidia cylindric or globular, borne in chains, smooth, hyaline or with light-yellow contents; oöspores globular, produced in various parts of the host, often separate from the conidia and forming more or less conspicuous masses; spores liberated by the rupture of the epidermis of the host; germination always by zoöspores.

Type species, *A. Cruciferarum* S. F. Gray = *Uredo candida* Pers.

Key to the species

Oöspore tuberculate; conidia globose or more or less cylindric, not as long as broad, if discoid the membrane of equal thickness throughout.
Oöspore with prominent tubercles; conidia similar, or the terminal smaller.
Oöspore with a few very large tubercles; conidial membrane of equal thickness throughout.
Conidia globular, hyaline.
Conidia and oöspores large; hosts Papaverales, mainly Brassicaceae. 1. *A. candida.*
Conidia and oöspores small; hosts Boraginaceae. 2. *A. sibirica.*
Conidia discoid, yellow. 3. *A. tropica.*

- **Oöspore with numerous small tubercles; conidial membrane with an equatorial thickening.** 4. *A. Ipomoeae-panduranae*.
- **Oöspore finely echinulate; conidia dissimilar, the terminal larger.** 5. *A. Lepigoni*.

- **Oöspore reticulate (unknown in nos. 8 and 9); conidia cylindric or elliptic, usually longer than broad, if discoid the membrane with an equatorial thickening.**
  - **Oöspore with the areolae unoccupied; conidial membrane with an equatorial thickening.**
    - **Oöspore coarsely reticulate; conidia elongate.**
      - **Oöspore with the reticulations tuberculate at their angles; conidia cylindric or with more or less rounded corners, hyaline, the terminal larger.**
        - **Conidial membrane always with an equatorial thickening.**
          - **Conidia more or less rounded; hosts Gentianaceae.** 6. *A. Swertiae*.
          - **Conidia cylindric; hosts Compositae.** 7. *A. Tragopogonis*.
        - **Conidial membrane of the terminal conidium only with an equatorial thickening.** 8. *A. quadrata*.
      - **Oöspore without tubercles; conidia obovoid or elliptic.**
        - **Conidia obovoid, the terminal larger.** 9. *A. Tillaeae*.
        - **Conidia elliptic, the terminal smaller.**
          - **Conidia uniformly hyaline.** 10. *A. Bliti*.
          - **Conidia light-yellow, the terminal with a dark equatorial band.** 11. *A. platensis*.
    - **Oöspore finely and shallowly reticulate, appearing pitted; conidia discoid, yellow.** 12. *A. occidentalis*.
  - **Oöspore with a tubercle in each areola; conidia cylindric, the membrane of uniform thickness.** 13. *A. Portulacae*.

1. ALBUGO CANDIDA (Pers.) Kuntze, Rev. Gen. Pl. 2: 658. 1891

Aecidium candidum Pers. in Gmelin, Syst. Nat. 2^{2}: 1473. 1791.
Uredo candida Pers. Syn. Meth. Fung. 223. 1801.
Uredo Cheiranthi Pers. Syn. Meth. Fung. 224. 1801.
Cystopus candidus Lév.; Berk. Jour. Hort. Soc. London 3: 271. 1848.

Sori on all parts of the host except the roots, white or rarely light-yellow, prominent and rather deep-seated in the tissues of the host, very variable in size and shape, often confluent and frequently producing marked distortion of the host; conidiophores hyaline, clavate, about 35–40 × 15–17 μ; conidia similar, globular, hyaline, with uniform thin walls, 15–18 μ; oöspores usually confined to the stems and fruits of the host, rarely in the leaves, chocolate-colored, about 40–55 μ; epispore thick, verrucose, or with low blunt ridges which are often confluent and irregularly branched.

This is the most widely distributed and by far the commonest species of the genus. Occurring as it does upon such a large number of hosts, a wide variation in characters is to be expected, yet an examination of numerous specimens, both American and foreign, has shown a remarkable stability of essential characters. The fungus as it grows upon *Bursa*, from which it was originally described, does not differ materially, either in habit or measurements, from that upon other species of *Brassicaceae*. In Europe the same fungus attacks various species of *Capparidaceae* and exhibits the same characters. An *Albugo* which occurs in Europe upon *Reseda* has also been referred to this species, from which it differs materially in habit, producing a much thinner and more superficial sorus than those produced upon the other two families of hosts. In the absence of oöspores and of perceptible difference in the conidia this disposition of the material had best be retained. The point of greatest variation in the species in America is that of oöspore-formation. The oöspores have not been observed on the majority of hosts and their location varies greatly in cases where they are known. Oöspores have been examined from the following hosts: *Brassica nigra* (stems), *Bursa Bursa-pastoris* (capsules), *Camelina microcarpa* (leaves), *Raphanus sativus* (capsules), *Roripa Armoracia* (leaves) and *Sophia pinnata* (leaves). Swingle* also reports oöspores from *Dentaria diphylla* (leaves), *Bursa Bursa-pastoris* (stems) and *Lepidium campestre* (stems). The morphology of this species has been studied by Wager† and Stevens.‡

ON BRASSICACEAE:

Arabis furcata S. Wats., Montana, *Rydberg & Bessey 4230;* Washington, *Suksdorf 266.*

Arabis lyrata L., New York, *Underwood.*

Arabis virginica (L.) Trel., Alabama, *Underwood;* Mississippi, *Tracy.*

Barbarea Barbarea (L.) MacM., California, *Heller 5108* (Fungi Columb. *1710*).

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*Jour. Myc. 7: 110, 111. 1892.

†Ann. Bot. 10: 297–342. *pl. 15, 16.* 1896.

‡Bot. Gaz. 32: 91, 98, 254. *pl. 2.* 1901.

Brassica arvensis (L.) B. S. P., South Dakota, *Chaney.*

Brassica campestris L., Massachussetts, *Humphrey* (Econ. Fungi *401*).

Brassica integrifolia (West.) O. E. Schultz, St. Croix, *Ricksecker 336.*

Brassica nigra (L.) Koch, Alabama, *Carver;* Illinois, *Burrill;* Indiana, *Olive;* Iowa, *Arthur;* Nebraska, *Williams;* New Jersey,* *Halsted* (Econ. Fungi *256*); South Dakota, *Griffiths* (W. Am. Fungi *46*).

Brassica sp., Wisconsin, *Pammel.*

Bursa Bursa-pastoris (L.) Britton, California, *Copeland;* Illinois, *Earle, Seymour;* Indiana, *Underwood 3734* (Ind. Fl. *98a*), * *Wilson;* Iowa, *Macbride;* Kansas, *Baker* (Fungi Columb. *2108*); Massachusetts, *Farlow* (N. Am. Fungi *204a*); Michigan, *Beal* (Econ. Fungi *257b*); Missouri, *Galloway, Galloway & Tracy, Trelease;* New Jersey, *Halsted* (Econ. Fungi *257a*), *Stevens;* New York, *Arthur, Britton, Underwood, Underwood & Cook* (Illust. Fungi *91*); Ohio, *Kellerman* (Ohio Fungi *122*); Ontario, *Dearness* (Fungi Columb. *133*); Wisconsin, *Pammel.*

Camelina microcarpa Andrz., Ohio, **Tyler* (Ohio Fungi *63*, on "*C. sativa* (L.) Crantz"); Virginia, *Murrill.*

Cardamine bulbosa (Schreb.) B. S. P., Indiana, *Olive.*

Cheiranthus asper Nutt., Oregon, *Suksdorf 220.*

Cheiranthus pacificum Sheldon, Oregon, *Sheldon.*

Dentaria diphylla Michx., New York, *Shear* (N. Y. Fungi *199*), *Underwood.*

Dentaria laciniata Muhl., South Carolina, *Rolfs 1687.*

Hesperis matronalis L., Ontario, *Dearness.*

Iodanthus pinnatifidus (Michx.) Steud., Indiana, *Arthur.*

Lepidium densiflorum Schrad., Nevada, *Baker 1087.*

Lepidium virginicum L., Florida, *Hume 34;* Illinois, *Earle;* Indiana, *Arthur, Underwood;* Kansas, *Bartholomew* (Fungi Columb. *2110*); Nebraska, *Williams;* New York, *Underwood;* Mississippi, *Tracy;* South Carolina, *Ravenel* (Fungi Car. 4: *93*), *Rolfs 1661;* Texas, *Ravenel 291a;* Bahama Is., *Hitchcock* (on "*Cakile maritima* Scop.?"); Bermuda, *Brown & Britton.*

Neslia paniculata Desv., Quebec, *Eggleston 2978.*

Raphanus sativus L., Illinois, *Breyfogle;* Indiana, *Underwood;* Iowa, *Arthur;* Kansas, **Bartholomew* (Fungi Columb. *1805*); New York, *Arthur,* **Underwood.*

Roripa Armoracia (L.) A. S. Hitchcock, Indiana, *Stewart,* * *Wilson;* Kansas, *Bartholomew* (Fungi Columb. *1806*), *Kellerman;* Massachussetts, *Seymour* (Econ. Fungi *454b*); Missouri, *Demetrio* (N. Am. Fungi *2420*); New Jersey, *Stevens;* New York, *Arthur, Holzworth, Underwood;* Ohio, *Kelsey* (Econ. Fungi *454a*); South Dakota, *Williams.*

Roripa hispida (Desv.) Britton, Illinois, *Arthur.*

Roripa obtusa (Nutt.) Britton, Kansas, *Bartholomew* (Fungi Columb. *2109*).

Roripa palustris (DC.) Bessey, Oregon, *Cusick 2600.*

Roripa sessiliflora (Nutt.) A. S. Hitchcock, Illinois, *Patterson;* Iowa, *Ehinger;* Kansas, *Bartholomew* (Fungi Columb. *2001*); Kentucky, *Price;* Tennessee, *Ruth 747.*

Roripa Walteri (Ell.) Greene, Florida, *Underwood;* Texas, *Bush 25, Lighthipe.*

Schoenocrambe linifolium (Nutt.) Greene, British Columbia, *? Macoun.*

Sisymbrium officinale (L). Scop., Indiana, *Arthur, Olive, Underwood, Wilson;* Massachusetts, *Farlow* (N. Am. Fungi *204b*); Missouri, *Bartholomew* (Fungi Columb. *2111*); New Jersey, *Halsted* (Ec. Fungi *259a*); New York, *Underwood 270a;* Nova Scotia, *Robinson 463a;* Ontario, *Dearness* (Econ. Fungi *259b*); Pennsylvania, *Britton;* Washington, *Parker, Piper;* Wisconsin, *Pammel.*

Sophia Hartwegiana (Tourn.) Greene, Montana, *Anderson, Kelsey.*

Sophia incisa (Engelm.) Greene, Colorado, *Baker, Earle & Tracy 1084;* Montana, *Kelsey.*

Sophia millefolia Rydb., Indiana, *Underwood.*

Sophia pinnata (Walt.) Britton, Arizona, * *Griffiths* (W. Am. Fungi *335*); Indiana, *Underwood* (Ind. Fl. *98b*); Durango, *Palmer.*

Thlaspi glaucum A. Nelson, Wyoming, *Nelson 4177.*

Thlaspi Nuttallii Rydb., Montana, *Blankinship.*

Brassicaceae sp., Montana, *Anderson.*

The following additional hosts are reported within our limits: *Arabis glabra* (L.) Bernh., *Brassica Napus* L., *B. oleracea* L., *Cakile edentula* (Bigel.) Hook., *Cheiranthus* sp. cult., *Coronopus* sp., *Draba caroliniana* Walt., *Lepidium campestre* (L.) R. Br., *L. sativum* L., *Roripa Nasturtium* (L.) A. S. Hitchcock, and *Sinapis alba* L.

TYPE LOCALITY: Europe, on *Thlaspi Bursa-pastoris* L. = *Bursa Bursa-pastoris* (L.) Britton.

DISTRIBUTION: Southern Canada to Mexico, Bermuda, and the West Indies. Also in South America, Europe, Asia, Africa, Australia, and New Zealand.

2. **Albugo sibirica** (Zalew.)

Cystopus sibiricus Zalew. Bot. Cent. **15**: 222. 1883.

No material of this species has been examined. It is known only from the original description, where it is recorded from some species of *Boraginaceae* from Siberia erroneously referred by Baron von Thümen to *Echinospermum Lappula.* It is said to differ from *A. candida* in its smaller measurements and in the structure of the epispore of the oöspore.

3. **Albugo tropica** (Lagerh.) Lagerh. ined.

Cystopus tropicus Lagerh.; Pat. & Lagerh. Bull. Soc. Myc. France **8**: 123. 1892.

This species was described from Ecuador on some unidentified species of *Piperaceae.* Material in the herbarium of the New York Botanical Garden from the type locality, and presumably a part of the original collection, is on *Peperomia pellucida* H.B.K., a species which is also widely distributed in the West Indies and Central America.

4. ALBUGO IPOMOEAE-PANDURANAE (Schwein.) Swing.
Jour. Myc. **7**: 112. 1891

Aecidium Ipomoeae-panduranae Schwein. Schr. Natur. Ges. Leipzig **1**: 69. 1822.

Caeoma convolvulatum Link, in Willd. Sp. Pl. **6**^{2}: 49. 1825.

Uredo Convolvulae Spreng. Syst. Veg. ed. 16. **4**: 572. 1827.

Aecidium Ipomeae Schwein.; Berk. Grevillea **3**: 60. 1874. (Hyponym.)

Cystopus Convolvulacearum Otth; Zalew. Bot. Cent. **15**: 223. 1883.

Cystopus Convolvulacearum Speg. Ann. Soc. Ci. Argent. **17**: 128. 1884.

Cystopus Ipomoeae-panduranae Stev. & Swing. Trans. Kan. Acad. Sci. **11**: 67. 1889.

Sori amphigenous or caulicolous, white or light-yellow, prominent, superficial, 0.5–20 mm., rounded, often confluent and frequently producing marked distortions of the host; conidiophores hyaline, clavate, unequally curved at base, about 15 × 30 µ; conidia short-cylindric, similar or the terminal more rounded, hyaline; the membrane with an equatorial thickening, usually very pronounced, 14–20 × 12–18 µ; oösporic sori separate from the conidial, caulicolous, rarely on the petioles, 1–2 × 5–6 cm. or even more, causing marked distortion of the host; oöspores light yellowish-brown, 25–55 µ; epispore papillate or with irregular, more or less curved ridges.

The position in the genus of this species has varied quite a little in the various elaborations which have appeared in recent years. Berlese and De-Toni * included it in *Cystopus Tragopogonis* from which it was separated by Saccardo.† According to Zalewski (*l. c.*) and Fischer ‡ it is placed next to *A. candida*, in the first instance on account of the structure of the epispore of the oöspore, and in the second as the result of inaccurate observations as to the thickness of the conidial membrane. In his *Monografia delle Peronosporacee*, Berlese attempts to accommodate the species to this varied treatment and so places *C. Ipomoeae-panduranae* next to *C. candida* on account of its conidial membrane having no equatorial thickening, and includes *C. Convolvulacearum* Speg. among those species which have an equatorially thickened conidial membrane, and at the same time cites various species of *Convolvulaceae* as hosts of *C. Tragopogonis*. An examination of co-type material of Spegazzini's species leaves no doubt concerning its identity with the North American species. Three packets of the material distributed by Ellis and Everhart in their North

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* Saccardo, Syll. Fung. 7: 234. 1888.

† Syll. Fung. 9: 340. 1891.

‡ Rabenh. Krypt. Fl. ed. 2. 4^1: 419. 1892.

American Fungi *1809* were examined. Berlese had previously * cited this as authentic material of the thin-walled species, but it proved to be the most pronouncedly thick-walled specimen at hand. In a conidium of 12 μ diameter the thickening frequently reaches 5 μ making the connecting strand of protoplasm but 2 μ.

The results of the morphological investigations of Stevens,† coupled with markings and general development of the epispore of the oöspore, lead to the conclusion that Zalewski was correct in his placing of the species. That the relationship of this species should long be in doubt is not surprising, as the oöspores which are borne in large galls on the stems of the host escaped notice until recently, while the conidia on the majority of hosts bear a superficial resemblance to those *A. Tragopogonis.* In all the material examined the conidia are short-cylindric, appearing in certain planes almost cubical, except in the case of those on *Ipomoea Batatas*, the sweet potato, which are very much more rounded than typically. It is not impossible that a distinct species occurs in this host.

ON CONVOLVULACEAE:

Calonyction aculeatum (L.) House, Florida, *Britton 419;* Oaxaca, *Holway 3735.*

Convolvulus incanus Vahl, Texas, *Heller 1910.*

Ipomoea Batatas (L.) Lam., Alabama, *Earle 2265 ;* Delaware, *Chester ;* Louisiana, *Langlois* (N. Am. Fungi *1809*) ; Mississippi, *Earle* (Econ. Fungi *47*) ; New Jersey, *Arthur, Ellis* (N. Am. Fungi *205*), *Stevens ;* South Carolina, *Ravenel* (Myc. Univ. *815*), *Rolfs 1685 ;* Porto Rico, *Underwood & Griggs 8.*

Ipomoea carolina Pursh, Louisiana, *Langlois 598 ;* South Carolina, *Rolfs.*

Ipomoea lacunosa L., ? Kansas, *Swingle ;* North Carolina, *coll. ign.*

Ipomoea leptophylla Torr., Kansas, * *Bartholomew* (Fungi Columb. *2003*).

Ipomoea mexicana A. Gray, New Mexico, *Mulford 920 ;* Mexico (city), *Pringle 6607.*

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* Icon. Fung. Phyc. 7. 1898.

† Bot. Gaz. 38 : 300–302. *f. 1, 2.* 1904.

Ipomoea pandurata L., Alabama, *Carver;* Delaware, *Commons;* Florida, *Hume 79*, *Nash 1889*, *Tracy 7155;* Georgia, *Underwood;* Illinois, *Hart;* Indiana, *Arthur*, *Olive;* Missouri, *Kellerman*, *Galloway*, *Tracy & Galloway;* New Jersey, * *Halsted 164* (Econ. Fungi *377*, also conidia as *336*), *Stevens;* Ontario, * *Dearness;* Virginia, *Paul* (Fungi Columb. *2004*).

Ipomoea Pes-caprae L., Bahamas, *Hitchcock;* Porto Rico, *Heller 1396*.

Ipomoea simulans Hanbury, Morelos, *Pringle 6565*.

Ipomoea triloba L., Arizona, *LeRoy*, *Pringle*.

Pharbitis hederacea (L.) Choisy, District of Columbia, *Williams;* Georgia, *Underwood;* Illinois, *Seymour;* Indiana, *Olive*, *Underwood;* Kansas, *Bartholomew* (Fungi Columb. *2002*); Kentucky, *Kellerman;* Louisiana, *Langlois 589;* Missouri, *Galloway*, *Pammel;* Nebraska, *Williams;* New Jersey, *Halsted* (Econ. Fungi *334b*, *334c*) *Stevens;* South Carolina, *Ravenel* (Fungi Am. *501*), *Rolfs 1686;* Virginia, *Seymour* (Econ. Fungi *334a*).

Pharbitis purpurea (L.) Voigt, Georgia, *Underwood;* Mississippi, *Tracy*.

Thyella tamnifolia (L.) Raf., Cuba, *Britton & Shafer 679*.

The following additional hosts are reported within our limits: *Convolvulus sepium* L., *Ipomoea incarnata* Vahl, *I. Jalapa* Michx., and *Quamoclit Quamoclit* (L.) Britton.

TYPE LOCALITY: North Carolina, on *Ipomoea "pandurana"* L.

DISTRIBUTION: Ontario to California, Central America and the West Indies. Also in South America, Europe, Asia and Africa.

5. ALBUGO LEPIGONI (de Bary) Kuntze, Rev. Gen. Pl. **2**: 658. 1891

Erysibe sphaerica β Caryophyllacearum Wallr. Fl. Crypt. Germ. **2**: 193. 1833.

Cystopus Lepigoni de Bary, in Rabenh. Fungi Europ. *483*. 1863.

Cystopus argentinus Speg. Bol. Acad. Ci. Cordoba **11**: 28. 1887.

Caulicolous or epiphyllous; sori rounded or elongate, 1–3 mm., yellowish; conidiophores clavate; conidia with the membrane of uniform thickness throughout, of two kinds, the terminal larger, hyaline or light-yellow, globular, 25 30 μ, the membrane about 5 μ thick, the lower smaller, hyaline, globose or ovoid, 18–25 × 18 23 μ, membrane about 1–2 μ thick; oöspores produced in the leaves and stems of the host, 50–65 μ, light-brown, finely and densely papillate or echinulate, the tubercles showing a tendency to be confluent and form short ridges.

Infesting as it does only the maritime *Caryophyllaceae*, this species is of necessity restricted in its habitat, yet appears to be as widely distributed as its chief host, *Tissa marina*, from which it was originally described. Material has been examined from various European countries and from Algiers. Hennings * also reports it from South America. What is presumably the same species is described as *Cystopus argentinus* by Spegazzini, who fails to give really distinguishing characters by which it can be separated from the present species. The morphology of the species has been studied by Ruhland.†

ON CARYOPHYLLACEAE:

Tissa leucantha (Robs.) Greene, California, *Parish 4462.*

Tissa marina (L.) Britton, California, *Parish;* New York, *Britton.*

TYPE LOCALITY: Germany, on *Arenaria marina* L. = *Tissa marina* (L.) Britton.

DISTRIBUTION: New York and California. Also in South America, Europe and Africa.

6. **Albugo Swertiae** (Berl. & Kom.)

Cystopus Convolvulacearum Speg. var. *Swertiae* Berl. & Kom.; Berl. Riv. Pat. Veg. 9: 26. 1900.

The only known locality for this species is the Amur region in eastern Siberia where it was collected on *Swertia connata* Schrenk by Komarof. An examination of this material shows the present species to be very closely related to *A. Tragopogonis*, yet quite distinct. Species of *Swertia* and the closely related genus *Frasera* have a wide distribution in North America.

7. ALBUGO TRAGOPOGONIS (DC.) S. F. Gray, Nat. Arr. Brit. Pl. 1: 540. 1821

Uredo candida β Tragopogi Pers. Syn. Meth. Fung. 233. 1801.
Uredo Tragopogi DC. Fl. France 2: 237. 1805.

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* Hedwigia 35: 210. 1896.

† Hedwigia 41: 179. 1902.

Cystopus spinulosus de Bary, in Rabenh. Fungi Europ. *479.* 1862.
Cystopus cubicus de Bary, Ann. Sci. Nat. IV. **20** : 132. 1863.
Cystopus pulverulentus B. & C. Jour. Linn. Soc. Bot. **10**: 357 1869.
Cystopus brasiliensis Speg. Bol. Acad. Ci. Cordoba **11** : 481. 1889.
Albugo spinulosa Kuntze, Rev. Gen. Pl. **2** : 658. 1891.
Cystopus Tragopogonis spinulosus Davis, Trans. Wis. Acad. **11**: 165. 1897. (Hyponym.)
Cystopus Mikaniae Speg. Ann. Mus. Nac. Buenos Aires III. **1**: 67. 1902.

Sori hypophyllous or caulicolous, prominent, deep-seated, white or yellowish, pulverulent, rounded or elongate, 1–3 × 1–8 mm.; conidiophores hyaline, clavate, about 12–15 × 40–50 μ; conidia light-yellow or hyaline, short-cylindric, the terminal larger and less angular than the lower, membrane with an equatorial thickening, 12–15 × 18–22 μ; oöspores produced in the stems and leaves of the host, dark-brown or almost black at maturity, very opaque, 44–68 μ; epispore reticulate, areolae 2 μ, wing bearing papillate tubercles at its angles.

The oöspores, which are produced in the leaves or rarely in the stems of the host, have been examined from a number of American and European specimens on hosts representing *Ambrosiaceae*, *Cichoriaceae* and various tribes of *Carduaceae.* The wing of the reticulation is lowest in specimens from the first families mentioned, while those on *Carduus* are scarcely more pronounced. The oöspores from various species of *Senecio* have the widest wing, while those from *Matricaria* are intermediate between those last mentioned. Oöspores produced on *Parthenium* have broader and lower reticulations than do the majority of specimens examined. It is however apparent that the American as well as the European material on the tribes *Cynareae*, *Senecioneae*, *Anthemideae* and *Heliantheae* belong to the same species. The only other North American hosts of this family for an *Albugo*, so far as is known, are of the tribe *Inuleae.* As no American material on these hosts contained oöspores, they were studied from European specimens and found to be identical with those produced on other members of *Carduaceae.* It appears from this that the American material from hosts of this tribe should be referred to the present species.

While there are minor differences in the conidia and in the relative size of the areolae of the oöspores, there do not appear to be sufficient grounds for the separation of the material examined into additional species. Especially is this true in regard to de Bary's *Cystopus spinulosus*, which is supposed to have pronounced spines on the oöspore. Dr. A. Fischer has examined the type specimen of this species and declares the character unreliable.* This is borne out by the more recent investigations of Dr. Magnus.† Since then Berlese has figured the spinulose oöspores,‡ using the material distributed by von Thümen (Myc. Univ. *1423*) on *Inula salicina* from Parma. The figures of the entire oöspores have a spinulose appearance due to the projection of the reticulations beyond the margin of the spore. The figure of an enlarged portion of the epispore looks very unlike anything found by me in the packet of this material, or, for that matter, in any other, as no such epispore has been observed by me in any specimen of the genus.

South American material from hosts of the tribes *Astereae* and *Eupatorieae* was examined. Oöspores similar to those produced on species of other tribes of this family were found on *Ageratum conyzoides* from Ecuador. From the same host Ule, in 1884, collected material in Brazil which has been referred to *Albugo brasiliensis* (Speg.) P. Hennings § and which was issued in Rabenhorst-Winter-Pazschke Fungi Europaei *3873* as *Cystopus Tragopogonis*. From a comparison of these two South American specimens it appears that Spegazzini's species is merely a synonym of *A. Tragopogonis*. Two other South American species, *Cystopus Mikaniae* Speg. and *Albugo Solivae* Schröt., have been described, but no material of either is at hand for examination. Inasmuch as the original descriptions of these species are scarcely distinctive and the hosts are closely related to species known to be hosts of *A. Tragopogonis*, it is very probable that they are also synonyms of that species. In addition to the above, another species, *Cystopus pulverulentus* B. & C., was described from an unidentified species of *Compositae* from Cuba. According to Dr. Farlow || the type "cannot be traced in Herb. Curtis by the number cited in the original

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* Rabenh. Krypt. Fl. ed. 2. 1^4: 422. 1892.

† Ber. Deutsch. Bot. Ges. 11: 327–330. *pl. 15*. 1893.

‡ Icon. Fung. Phyc. *pl. 5*. 1898.

§ Hedwigia 35: 212. 1896.

|| Bibl. Index N. Am. Fungi 1: 177. 1901.

description." As the latter is too vague to allow of a more definite determination than would the mere citation of the host, this species had probably best be placed with the present one. The morphology of this species has been studied by Stevens.*

ON AMBROSIACEAE:

Ambrosia artemisiaefolia L., Alabama, **Carver 180;* Illinois, **Hart;* Kansas, **Swingle 1667;* Massachusetts, **Farlow* (N. Am. Fungi *2056*), **Seymour;* Missouri, **Demetrio* (N. Am. Fungi *2421*); New Jersey, **Halsted* (Econ. Fungi *291a*), *Stevens;* New York, *Underwood;* South Dakota, *Chaney*, *Williams* (Econ. Fungi *291b*); Wisconsin, *Pammel.*

Ambrosia psilostachya DC., Iowa, **Macbride;* South Dakota, *Rydberg 798;* Utah, *Macbride.*

Ambrosia trifida L., Kansas, *Swingle.*

Gaertneria acanthocarpa (Hook.) Britton, Utah, **Garrett* (Fungi Columb. *2205*).

Iva ambrosiaefolia A. Gray, Arizona, **Griffiths* (W. Am. Fungi *336*, on "*Franseria tenuifolia* Gray"); New Mexico, *Tracy 810.*

Iva ciliata Willd., Illinois, **Hart;* Missouri, **Hart.*

ON CARDUACEAE:

Artemisia biennis Willd., Montana, *Anderson & Kelsey.*

Carduus arvensis (L.) Robins., New York, *Arthur*, *Brown*, **Halsted* (Econ. Fungi *302*), *Stevens*, *Underwood;* Ontario, *Dearness.*

Carduus lanceolatus L., Newfoundland, *? Waghorne.*

Carduus muticus (Michx.) Pers., Minnesota, *Holway 241;* Ontario, *Dearness.*

Carduus spinosissimus Walt., Louisiana, **Langlois 335.*

Matricaria matricarioides (Less.) Porter, California, **Abrams 2487;* Oregon, **Lloyd.*

Parthenium integrifolium L., Iowa, **Arthur.*

Parthenium repens Eggert, Kansas, *Hitchcock 1086.*

? Senecio cymbalaroides Nutt., Montana, *Kelsey.*

Senecio Hartianus Heller, Colorado, *Rydberg & Vreeland 5499.*

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* Bot. Gaz. 32: 85, 97, 259. *pl. 3; pl. 4, f. 43, 53.* 1901

Senecio oblanceolatus Rydb., Colorado, *Demetrio* (N. Am. Fungi *2208*, on "*S. aureus*." The host is mixed but chiefly as cited here).

Senecio peninsularis Vasey & Rose, Baja California, **Palmer 659*.

Senecio serra Hook., Montana, **Kelsey*; Washington, **Piper*.

ON CICHORIACEAE:

Tragopogon porrifolius L., Massachusetts, *Farlow* (N. Am. Fungi *205b*); New Jersey, *Halsted* (Econ. Fungi *445*); New Mexico, **Mulford 1285a*; New York, *Arthur*, *Underwood*.

The following additional hosts are reported within our limits: *Antennaria plantaginifolia* (L.) Richards., *Artemisia canadensis* Michx., *Gaertneria discolor* (Nutt.) Kuntze, *Senecio aureus* L., *S. lugens* Richards., and *S. serra integriusculus* A. Gray.

TYPE LOCALITY: Europe, on *Tragopogon porrifolius* L.

DISTRIBUTION: Newfoundland to Washington, Baja California and Alabama. Also in South America, Europe, Asia, Africa and Australia.

8. ALBUGO QUADRATA (Kalchb. & Cooke) Kuntze, Rev. Gen. Pl. 2: 658. 1891

This species is known only from Cape Colony, where it was collected on *Herpestis verticillaris* Nees by McOwen. The conidia are most nearly like those of *A. Tragopogonis*, but in the absence of oöspores it is impossible satisfactorily to refer the species to a place in the genus.

9. **Albugo Tillaeae** (Lagerh.)

Cystopus Tillaeae Lagerh.; Pat. & Lagerh. Bull. Soc. Myc. France 8: 167. 1891.

No material of this species has been examined; but the description indicates a close relationship with *A. Bliti*. It is known only from Quito, Ecuador, the type locality, where it occurs on *Tillaea rubescens* H.B.K. Species of this genus occur sparingly in tropical America.

10. ALBUGO BLITI (Biv.) Kuntze, Rev. Gen. Pl. 2: 658. 1891

Uredo Bliti Biv. Stirp. Rar. Sicilia **3**: 11. 1815.
Caeoma Amaranthi Schwein. Trans. Am. Phil. Soc. II. **4**: 292. 1832.
Cystopus Bliti de Bary, Ann. Sci. Nat. IV. **20**: 131. 1863.
Cystopus Amaranthi Berk. Grevillea **3**: 58. 1874.
Cystopus Amaranthacearum Zalew. Bot. Cent. **15**: 223. 1883.
Cystopus Cyathulae Winter; Roum. Rev. Myc. **11**: 66. 1889.

Sori amphigenous, white or very light-yellow, prominent, subsuperficial, rounded, sometimes confluent, 1–10 mm.; conidiophores hyaline, cylindric, about 15 x 60 μ; conidia hyaline, elliptic, the terminal smaller, globular; the membrane with an equatorial thickening, 8–15 x 15–20 μ; oöspores produced in the leaves of the host, dark-brown, 50–60 μ, averaging 55 μ; epispore coarsely reticulate, areolae 6–8 μ.

According to Zalewski (*l. c.*) there are two species of *Albugo* on the genus *Amaranthus*, the first, *Cystopus Bliti*, being confined to *Amaranthus Blitum*, while the second, *C. Amaranthacearum*, infests the other species of the genus. The points of distinction are confined to the oöspore and are of questionable value, although their reliability could not be disproved on account of a lack of authentic European material. The oöspores of *C. Bliti* are said to be formed only on the stem of the host, to vary from light- to dark-brown in color and to have irregular reticulations. Those of *C. Amaranthacearum* are borne in the leaves of the host, are of a uniform dark-brown and are regularly reticulate. The only specimen at hand on undoubted *Amaranthus Blitum* contains a few detached leaves with conidia only. That the place of oöspore-production cannot be regarded as of taxonomic value is evident, as this varies with the host in *A. candida* and in the same host in *A. Portulacae*. The color of the oöspore depends entirely upon maturity and may show remarkable variation just as do those of the present species in all specimens examined. The pattern of the reticulations cannot be taken as a taxonomic character unless accompanied by other marked distinctions, as the pattern is practically the same, or at most a modification of the same basic pattern, in *A. Bliti*, *A. platensis*, and *A. Portulacae*. In all of these species it is by no means uncommon to find that a number of contiguous areolae are only imperfectly separated from each other by simple or even branched reticulations which end blindly before reaching the opposite side of the areola, thus producing a more or less complex labyrinth of ridges in place of the regular pentagonal or hexagonal reticulations which are typical of this group of species. The morphology of this species has been studied by Stevens.*

ON AMARANTHACEAE:

Acnida tamariscina tuberculata (Moq.) Uline & Bray, Iowa, **Arthur.*

Amaranthus Bigelovii Uline & Bray, Texas, *Heller 1867.*

Amaranthus blitoides S. Wats., California, *Underwood;* Montana, *Reynolds;* Washington, **Suksdorf 182.*

Amaranthus emarginatus Salzm., Guadeloupe, *Duss 4067.*

Amaranthus graecizans L., Montana, **Anderson.*

Amaranthus hybridus L., Alabama, *Earle 2264;* Florida, *Hitchcock 293;* Illinois, *Hart,* **Waite;* Indiana, *Underwood* (Ind. Fl. *99*), *Wilson;* Iowa, **Hitchcock;* Kansas, *Norton 425;* Missouri, *Bush 316,* * *Tracy & Galloway;* Nebraska, *Williams;* New Jersey, * *Halsted* (Econ. Fungi *352*), **Stevens;* New York, *Peck* (Roum. Fungi Sel. *4551*), *Shear* (N. Y. Fungi *198*), *Underwood;* Wisconsin, * *Davis, Pammel.*

Amaranthus Palmeri S. Wats., New Mexico, *Metcalfe 719;* Chihuahua, **Pringle 1112;* Jalisco, *Palmer.*

Amaranthus retroflexus L., Alabama, *Earle;* Illinois, *Burrill, Earle;* Indiana, * *Bolley, Olive;* Iowa, * *Arthur;* Massachussetts, * *Farlow* (N. Am. Fungi *206*), *Seymour* (Econ. Fungi *254b*); New Jersey, * *Stevens;* New York, *Halsted* (Econ. Fungi *354a*), *Jelliffe, Peck* (Myc. Univ. *619*), *Underwood 396;* Ontario, *Dearness* (Fungi Columb. *46*); South Dakota, * *Griffiths* (W. Am. Fungi *33*); Wisconsin, *Pammel.*

Amaranthus spinosus L., Illinois, * *Earle;* Indiana, *Rose;* Louisiana, *Ball 662;* Texas, * *Long* (Fungi Columb.

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* Bot. Gaz. **28**: 149, 233. *pl. 11–15.* 1900.

1709), *Stanfield;* Virginia, *Heller 1023;* Mexico, *Berlandier;* Porto Rico, *Millspaugh.*

Amaranthus tristis L., Grenada, *Broadway;* St. Croix, *Ricksecker 109.*

Amaranthus viridis L., Florida, * *Hitchcock 298, Nash 2179.*

Cladothrix lanuginosa (Moq.) Nutt., Kansas, *Hitchcock 431;* New Mexico, *Wooton;* Mexico, *Berlandier.*

Cyathula lappulacea Moq., New York, *Peck* (Roum. Fungi Sel. *4863*).

Also reported from within our limits on the following additional hosts: *Acnida cannabina* L., *A. tamariscina* (Nutt.) Willd., *Amaranthus crispus* (Lesp. & Thev.) Braun, and *A. hybridus paniculatus* (L.) Uline & Bray.

TYPE LOCALITY: Sicily, on *Amaranthus Blitum* L.

DISTRIBUTION: Vermont to Washington, Mexico, Florida and the West Indies. Also in South America, Europe, Asia and Africa.

11. ALBUGO PLATENSIS (Speg.) Swing. Jour. Myc. 7: 113. 1892

Cystopus platensis Speg. Rev. Argent. Hist. Nat. 1: 32. 1891.

Hypophyllous, sori at first pallid, later surrounded by a purplish line, irregular in outline, 1–5 mm., scattered or gregarious, prominent; conidiophores cylindric, about 40–45 × 15 μ; conidia elliptic, 20–22 × 18–20 μ, very light-yellow, the membrane with an equatorial thickening which is darker-colored in the smaller terminal conidium; oöspores borne in the leaves of the host, very opaque, very dark-brown, globular, 55–85 μ, averaging 60 μ, finely reticulate, areolae about 4 μ.

This species is very closely related to *A. Bliti*, from which it is, however, quite distinct. The conidia of *A. Bliti* are hyaline and white in mass while those of *A. platensis* are slightly colored, appearing light-yellow in mass while the apical conidium has a darkened equatorial band. The oöspores, which are produced in the leaves of the host in both species, are very similar and at first sight indistinguishable. Those of *A. platensis* are very dark-brown, so opaque that until treated with HCl they appear as black grains, and are finely reticulate, while those of *A. Bliti* are lighter in color, less opaque, slightly smaller in size and more coarsely reticulate, the areolae being from one third to one half larger.

ON ALLIONIACEAE:

Boerhaavia anisophylla A. Gray, New Mexico, *Wooton 462.*

? *Boerhaavia diffusa* L., McComb's Expedition, *Newberry.*

Boerhaavia erecta L., Florida, *Swingle 4139;* Sonora, *Palmer;* Jamaica, *Harris 6853;* St. Croix, *Ricksecker 401.*

Boerhaavia hirsuta Willd., Texas, * *Long* (Fungi Columb. *1605*, on "*B. decumbens*"); Yucatan, *Gaumer 309;* Cuba, *Britton & Shafer 1;* Guadeloupe, *Duss 2174;* Porto Rico, *Goll 536.*

Boerhaavia paniculata Rich., Culebra, *Britton & Wheeler 2.*

Boerhaavia spicata Choisy, Arizona, *Griffiths 2071;* New Mexican, *Wooton.*

Boerhaavia Xanti S. Wats., Sonora, *Palmer.*

Wedelia incarnata (L.) Kuntze, Arizona, *Rusby;* New Mexico, *Skehan 102*, *Wooton;* Texas, *Seler 1901;* Utah, *Goodding 809;* San Luis Potosi, *Schaffner 562.*

Reported from within our limits on the following additional hosts: *Boerhaavia Sonorae* Rose and *B. viscosa* Lag. & Rodr.

TYPE LOCALITY: Buenos Aires, Argentina, on *Boerhaavia hirsuta* Willd.

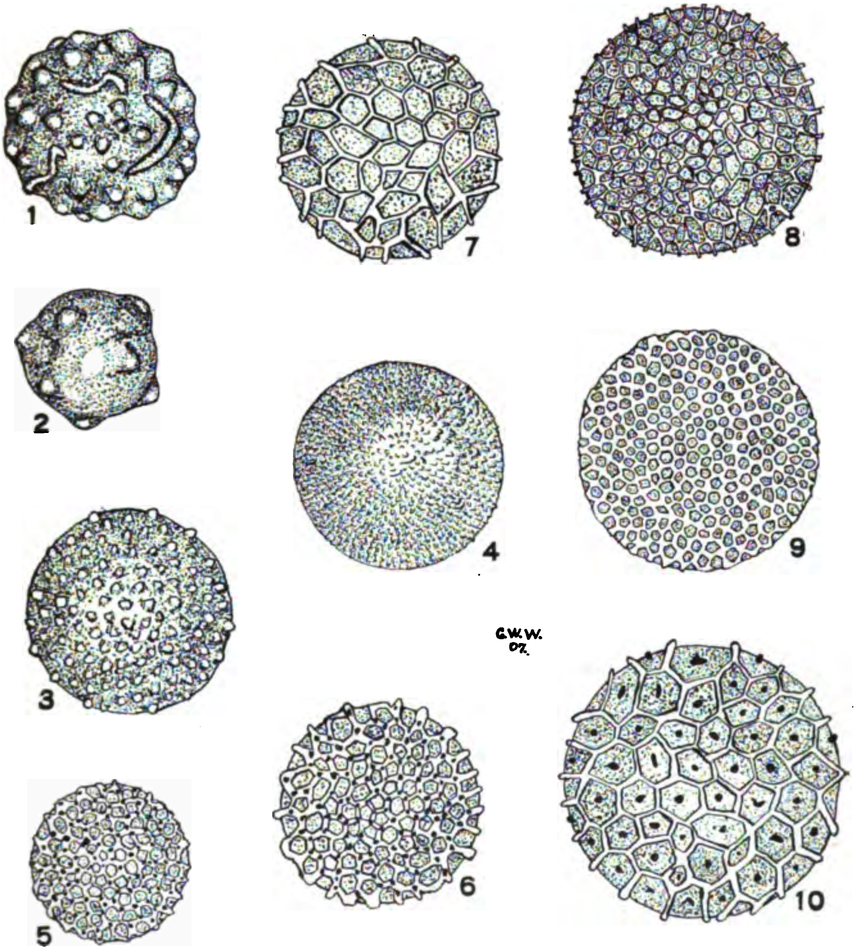
DISTRIBUTION: Utah to peninsular Florida, southern Mexico and the West Indies. Also in South America, Asia and Africa.

12. **Albugo occidentalis** sp. nov.

Soris hypophyllis, subrotundis vel irregularibus, rarius confluentibus, superficialibus, prominentibus, subflavidis, 1–3 mm. crassis; conidiophoris cylindraceis, circa 12 × 40 μ; conidiis flavidis, breviter cylindraceis, 14–20 × 8–16 μ, membrana hyalina, ad medium annulo cincta; oosporis in hospitis foliis, globosis, luteo-brunneis, regulariter tenuiterque reticulatis, 50–60 μ diametro, areolis pentagonis vel hexagonis, circa 2 μ crassis.

Sori hypophyllous, rounded or irregular in outline, sometimes confluent, superficial, prominent, yellowish, 1–3 mm.; conidiophores cylindric, about 12 × 40 μ; conidia discoid, the membrane hyaline with an equatorial thickening, contents yellow, 14–20 × 8–16 μ; oöspores borne in the leaves of the host with the conidia, globular, 50–60 μ, yellowish-brown, very closely and shallowly reticulate, areolae about 2 μ.

Type in herbarium of the New York Botanical Garden, *L. M. Underwood & A. D. Selby 108*, from the hills about Box Cañon,



Oöspores of *Albugo*. (All × 500.)

1. *A. candida*, from *Raphanus sativus*, in Fungi Columbiani *1805*.
2. *A. tropica*, from *Peperomia pellucida*, Ecuador, ex Herb. Lagerheim.
3. *A. Ipomoeae-panduranae*, from *Ipomoea pandurata*, in Economic Fungi *337*.
4. *A. Lepigoni*, from *Lepigonum medium*, in Fungi Europaei *483*.
5. *A. Swertiae*, from *Swertia connata*, in Fungi Rossiae Exsiccati *301*.
6. *A. Tragopogonis*, from *Tragopogon porrifolius*, Mulford *1285a*.
7. *A. Bliti*, from *Amaranthus hybridus*, in Economic Fungi *352*.
8. *A. platensis*, from *Boerhaavia decumbens*, in Fungi Columbiani *1605*.
9. *A. occidentalis*, from *Blitum capitatum*, type specimen, Underwood & Selby *108*.
10. *A. Portulacae*, from *Portulaca oleracea*, in West American Fungi *31*.

west of Ouray, Colorado, September 8, 1901, at an altitude of 2,300–2,500 m. On *Blitum capitatum* L.

ON CHENOPODIACEAE:

Blitum capitatum L., Colorado, * *Underwood & Selby 108.* (Type.)

Chenopodium rubrum L., Montana, *Kelsey.*

This material was referred in the herbarium of the New York Botanical Garden to *A. Bliti*, but a superficial examination of the conidia was sufficient to throw doubt upon the correctness of the identification. The conidia differ in their yellow color and in their discoid form from those of *A. Bliti*, and from those of *A. platensis* in the brighter color and uniformly hyaline membrane, while in outline they approach most nearly to those of *A. tropica*. The oöspores, however, are markedly different from those of these species or of any other member of the genus. They are very closely reticulate, with the areolae so shallow as at first sight to give the appearance of pitting rather than reticulations. This is our rarest and most local species, yet none are more markedly distinct. It is represented in the material examined by only two collections, while but one American mycologist has referred to an *Albugo* which could belong to the present species. The inclusion by Berlese and DeToni * of *Atriplex* among the hosts of *A. Bliti* appears to be the first mention of a species of this genus on a Chenopodiaceous host. No locality is given nor can the host be traced by any bibliographical assistance at hand. Later Pammel † reported the occurrence of *A. Bliti* upon the sugar beet in Iowa and mentions its occurence on *Blitum*. He figures the conidia from *Beta* and the oöspores from *Amaranthus*, as they were not found on the former host. Later the same author ‡ cites references to the occurrence of *A. Bliti* on *Chenopodium* in Europe, but no light has been gained from them.

DISTRIBUTION: Montana and Colorado. Probably also in Iowa and Europe.

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* Sacc. Syll. Fung. 7: 236. 1888.

† Bull. Iowa Agr. Expr. Sta. 15: 236. *pl. 6.* 1891.

‡ Jour. Myc. 7: 102. 1892.

13. ALBUGO PORTULACAE (DC.) Kuntze, Rev. Gen. Pl. 2: 658. 1891

Uredo Portulacae DC. Fl. France 5: 88. 1815.

Cystopus Portulacae de Bary, Ann. Sci. Nat. IV. 20: 131. 1863.

Sori white or yellowish, on all parts of the host except the roots, rounded or irregular in outline, up to 5 mm.; conidiophores clavate, about 9 x 25 μ, hyaline; conidia dissimilar, the terminal larger, cylindrical and papillate, the basal smaller, subglobular, about 12–15 x 15–22 μ, walls hyaline, contents light-yellow; oöspores borne in the stems and leaves, globular, dark-brown, about 70 μ; epispore regularly reticulated, with short ridges or papillate tubercles in the areas.

This species is restricted throughout its range to a single host, upon which it does not appear to be very common, although the distribution of both host and fungus is probably coextensive. It is easily distinguished from related species by the uniform thickness of the conidial membrane and by the tubercles in the areolae of the oöspore. The morphology of this species has been studied by Stevens.*

ON PORTULACACEAE:

Portulaca oleracea L., Connecticut, *Underwood;* Georgia, * *Underwood;* Illinois, *Blount*, *Burrill*, * *Earle*, *Waite;* Indiana, *Bolley*, *Olive*, * *Underwood;* Iowa, * *Arthur;* Missouri, *Galloway;* New Jersey, *Ellis* (N. Am. Fungi *1808*), *Halsted* (Econ. Fungi *264a*); New York, *Underwood;* New Mexico, * *Cockerell;* Ohio, *Tyler* (Ohio Fungi *83*); Ontario, *Dearness* (Fungi Columb. *45*, Econ. Fungi *264b*); South Carolina, *Ravenel* (Fungi Am. *500*); South Dakota, * *Chaney*, * *Griffiths* (W. Am. Fungi *31*).

TYPE LOCALITY: France, on *Portulaca oleracea* L.

DISTRIBUTION: Vermont to South Dakota, New Mexico and Georgia. Also in South America, Europe, Asia and Africa.

SPECIES EXCLUDENDAE

While several names have been proposed under this genus which for one reason or another cannot be retained, it appears scarcely necessary to mention any of these which have not gained admission to Saccardo's *Sylloge Fungorum*.

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* Bot. Gaz. 32: 79, 97, 254. *pl. 1; pl. 4, f. 44–46, 48–50.* 1901.

Cystopus Euphorbiae Cooke & Massee, Grevillea **20**: 106. 1892.

The roughened conidia bespeak a closer relationship with the Uredinales than with the present genus.

Cystopus Salsolae and *C. Schlechteri* P. Sydow, Hedwigia Beibl. **38**: 142. 1889.

Authentic material of both these species has been examined. In both instances the host is covered with white spots which closely simulate the sori of *Albugo* and answer to the description in the diagnoses of these species. A microscopic examination of these spots failed to show anything except crystals of some chemical. These answer fairly well to the measurements given, but show no membrane or other parts as described, for the spores. Nothing more similar to conidia, however, was observed. The spores described as oöspores are present in fair abundance in the material of both species. They are borne apparently singly, at the apex of isolated conidiophores, and are the conidia of some species of Hyphomycetes and rather closely related to *Coniosporium* or *Torula*.

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COSTA RICAN ORCHIDS—I

By GEORGE VALENTINE NASH

NEW YORK
1907

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 118–124, *pl. 7, 8.* 1907]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 34: 113-124, *pl. 7, 8, 11.* 1907.]

Costa Rican orchids — I

GEORGE VALENTINE NASH

(WITH PLATES 7 AND 8)

In the months of April and May, 1906, Mr. William R. Maxon, of the U. S. National Museum, during a furlough from that institution, made, in the interests of the New York Botanical Garden, an exploration of portions of Costa Rica. Much attention was given to the collection of living plants, especially in the families *Cactaceae*, *Orchidaceae*, and *Bromeliaceae*, which furnished many specimens of great interest. The material was carefully collected and excellently packed, so that little harm came to it during the long journey, and it arrived in fine condition.

The orchids were especially well represented. Of many of these no herbarium material was secured, as at the time of collection they were not in flower. A number of these have now come into flower and others will undoubtedly do so, and it is the object of this and succeeding articles to report upon them.

Mr. Maxon gave, in the form of a report to the Director-in-chief of the Garden, an account of his explorations and many of the places visited by him, in the *Journal of the New York Botanical Garden* for August, 1906. As this may be inaccessible to many, the locations of some of the places referred to, which do not appear in the atlases ordinarily at hand, are given here, extracted in the main from Mr. Maxon's published account.

The country was entered at Port Limon, the eastern terminus of the Northern Railway of Costa Rica, which runs in a general westerly direction through the low lands of Siquirres, and then south and west along the gorge of the Rio Reventazon, traversing the region of Juan Viñas and Santiago. It then proceeds through Cartago to San José, the capital of the country, beyond which place Mr. Maxon did not proceed by rail. With this place as his base, excursions were made into the neighboring country, including the valley of the Rio Tirivi and the estate of La Palma, a few miles northeast of the city. While here a visit was made to Santo Domingo de San Mateo, at an elevation of about 300 meters, a little to the westward of San José, and the only locality visited west of that city. Mr. Maxon reports it as an exceedingly dry region at the time of his visit, but without a characteristic desert vegetation. A number of orchids were secured here, some of them of exceeding interest.

At Cartago, which has an elevation of about 1450 meters, considerable collecting was done, especially of living plants of orchids and bromeliads. Collections were also made at Santiago, a few miles to the eastward of Cartago. At Turrialba, on the border of the *tierra caliente*, some time was spent, and from that place a trip was made to the low humid forest on the border of the Rio Reventazon, at an altitude of about 600 meters. While at Cartago an excursion was also made to Coliblanco, an estate lying at the base of the volcano of Turrialba. One of the principal excurions while at Cartago was to the Finca Navarro, at an altitude of 1,350 meters. Navarro lies about seven miles to the southeast in a mountain valley a little lower than Cartago, at the junction of the Agua Caliente and the Rio Naranjo. Many of the orchids were secured at this point.

Judging from Mr. Maxon's collections and from recent publications, the orchid flora of Costa Rica must be exceedingly rich. It is to be hoped that explorations so well begun may be continued, for such continuation is certain to yield valuable results. Following are some of the orchids secured by Mr. Maxon, which may be safely reported upon at present.

CORYMBIS FLAVA (Sw.) Hemsley, Biol. Cent. Am. Bot. 3: 297. 1884

Serapias flava Sw. Prod. 119. 1788.
Neottia flava Sw. Fl. Ind. Occ. 3: 1417. 1806.

On moist forested slope, Finca Navarro, *no. 644.* Hemsley, *l. c.*, reports this from Mirador, southern Mexico, and from Chiriqui, Panama. Its detection in Costa Rica, therefore, was to be expected. Mr. Maxon in his field notes describes the flowers as yellow. This species was originally described from Jamaica.

PLEUROTHALLIS POLYLIRIA Endres & Reichenb. f. Gard. Chron. 32: 1483. 1871

On tree bordering the Agua Caliente, Finca Navarro, *no. 702A.* This pretty species, one of the larger members of the genus, is a free bloomer, sending up usually several racemes from the same leaf. The flowers hang in a somewhat secund manner, giving the inflorescence an appearance resembling that of the lily-of-the-valley.

Originally described from fresh living material sent by W. W. Saunders to Reichenbach, who does not state from what country the plant was derived. A herbarium specimen, collected in Costa Rica by M. Endres, is, however, referred to as being the same, so that the indications are that that country is the native home of this interesting plant.

PLEUROTHALLIS MINAX Reichenb. f. Bonplandia 2: 24. 1854

? *Pleurothallis plumosa* Lindl. Bot. Reg. 28: Misc. 72. 1842.

On a tree bordering the Agua Caliente, Finca Navarro, *no. 707.* I have taken up with some hesitation Reichenbach's name for this plant, instead of that given by Lindley, who originally described the flowers as "green, with a little purple dotting on the inside," and gave the home of his plant as Trinidad. Later (*Folia Orch. Pleurothallis* 27. 1859) he makes this statement: "Flowers green in gardens, orange coloured wild," and refers to his species a specimen collected by Fendler in Venezuela, *no. 2152*, and also material secured by Wagener at Caracas. He further remarks thus: "The dissection of a flower of his *P. minax* given me by Prof. Rchb. and Fendler's specimens show that plant not to be distinct from *P. plumosa.*" A specimen secured by Wagener at Caracas, at an elevation of 5000 feet, and presumably the one to which Lindley refers above, was the basis of *P. minax.* The plant which Mr. Maxon secured came into flower in the early part of November of last year, the flowers being of a dull orange, thus closely approaching the "dottergelb" applied by Reichenbach in describing the color of the flowers of his species, and incidentally showing that the Costa Rican plants, at all events, do not produce green flowers in cultivation. So it does not seem possible to reconcile this with the green flowers originally accredited to *P. plumosa*, nor does it seem likely that a plant from Trinidad should be identical with one from an elevation, in practically the same latitude, of 5000 feet. The short velvety pubescence of the peduncle, axis of the raceme, bracts and flowers, and the color and details of the flowers, especially those of the lip, of *P. minax* so closely coincide with those in Mr. Maxon's plant that I cannot but place it there, rather than take up for it the name of *P. plumosa*, as done by Hemsley (Biol. Cent. Am. Bot. **3**: 201. 1883) for a specimen collected by Wendland, also in Costa Rica. Perhaps Lindley was wrong as to the color of his flowers, although he indicates that he was dealing with fresh material, or he may have been mistaken as to the country from which the material came — at all events, it seems better now to adopt for this Costa Rican plant a name which can be applied with some certainty, rather than a doubtful one. A comparison with Lindley's type may some time definitely settle the question.

ISOCHILUS LINEARIS (Jacq.) R. Br. in Ait. Hort. Kew.
ed. 2. **5**: 209. 1813

Epidendrum lineare Jacq. Select. Stirp. Am. Hist. 221. *pl. 131. f. 1.* 1763.

Partially shaded rocky bank, Santiago, *no. 108.* Widely distributed in tropical America, but originally described from Martinique.

PONERA AMETHYSTINA Reichenb. f. in Saund.
Ref. Bot. *pl. 93.* 1869

Santo Domingo de San Mateo. On tree-trunk by Rio Machuco, *no. 545;* and on tree trunk near Rio Grande, *no. 570.* This region is described by the collector as an exceedingly dry one but without a characteristic desert vegetation. An interesting find. The plant was originally figured and described from living material, secured by Mr. Skinner at Santa Fé de Veraguas, Panama, which flowered in the collection of Mr. W. W. Saunders. Its detection in the above locality extends its range considerably to the north and west of its place of discovery. The flowers in our specimens have the sepals and petals more acute and the terminal lobe of the lip somewhat narrower than indicated in the plate referred to above, but they agree essentially in all the other particulars. The hollow at the base of the column, represented in the drawing and rather questionably referred to by Reichenbach, is quite manifest in the flowers of the Costa Rican plant. The lip, however, has no such hollow at the base, but, on the contrary, is noticeably thickened at that point.

EPIDENDRUM COCHLEATUM L. Sp. Pl. ed. 2. 1351. 1763

On trees in humid forest, Santiago, *no. 101*. On tree-trunk in forest, Turrialba, *no. 179*. Quite widely distributed in tropical America, ranging from southern Mexico to Venezuela, and common in the West Indies; also frequent in southern Florida.

The type locality is the Bahamas. Linnaeus appears to have had two things in his species. He gives three citations, as follows: Sloane, Jam. 250. *pl. 121. f. 2;* Catesby, Car. 2: 88. *pl. 88;* and Plum. Pl. Am. Icon. *pl. 185. f. 2.* In his description he says: "nectario cordato." This effectually disposes of the first citation above, as that figure has a broadly obcordate or almost orbicular lip. The plant is figured, moreover, with very short round pseudobulbs, and has the sepals and petals represented as much broader and of a different shape than those in the plant commonly accepted as this species. The flowers are also described by Sloane as "reddish purple." One could hardly mistake this figure for what is commonly known as *E. cochleatum.* The other two figures cited represent what has been widely known as this species, that of Catesby being in color and allowing of no doubt. The lip is also decidedly cordate, as called for by Linnaeus, thus permitting us to retain the common conception of this species. Catesby's plant was from the Bahamas, and Plumier gives no origin for his, but cites Catesby's plate; the type locality is thus pretty clearly as indicated above.

EPIDENDRUM OCHRACEUM Lindl. Bot. Reg. **24**: Misc. 14. *pl. 26.* 1838

On trees in humid forest, Santiago, *no. 104.* First received by Lindley from the garden of Sir Charles Lemon, who received the living material from George U. Skinner, who had collected it in Guatemala. It is widely distributed in Central America.

EPIDENDRUM PALEACEUM (Lindl.) Reichenb. f. Beitr. Orch. Cent. Am. 80. 1866

Dinema paleaceum Lindl. Bot. Reg. **26**: Misc. 51. 1840.
Epidendrum auritum Lindl. Bot. Reg. **29**: Misc. 4. 1843.

On branches of fallen tree-tops, Turrialba, *no. 164.* Rather extensively distributed from Guiana to southern Mexico, and originally described from Guatemalan material. This is the second time this little species has been brought to us by collectors; Mr. Percy Wilson secured it in Honduras in 1903. It is interesting to note that Wendland also obtained specimens of this plant at Turrialba in 1857.

LAELIA RUBESCENS Lindl. Bot. Reg. **26**: Misc. 20. *pl. 41.* 1840

Under cultivation in the garden of Mr. P. Biolley, at San José, *no. 358.* Mr. Biolley secured the plant in January of the same year at Uricuaja, on the Pacific coast, at an altitude of about 200 m. When this species was first described its native country was unknown, but it was supposed to be Mexico, a supposition which was later verified. Owing to the variability of its flowers and pseudobulbs, two species described subsequently by Lindley, *L. acuminata* and *L. peduncularis*, are usually referred here. Under this broad conception it ranges from Mexico throughout Central America to Costa Rica.

EPIDENDRUM STAMFORDIANUM Batem. Orch. Mex. & Guat. *pl. 11.* 1838

On horizontal branch of a tree, Santo Domingo de San Mateo, *no. 600A.* This came mixed with a fine plant of *Schomburgkia* sp. (*no. 600*). Another specimen, *no. 355*, which was under cultivation at San José, was also secured from Mr. P. Biolley, in whose garden at that place it was. Mr. Biolley secured it at Uricuajo, at an altitude of about 200 m., on the Pacific coast, in January of the same year.

The species was originally found by George U. Skinner along the shores of Lake Izabal, near Izabal, Guatemala. He sent plants in 1837 to England, where they flowered the following year, furnishing the material from which the original description and illustration referred to above were drawn. The flowering of this plant caused considerable excitement among the orchidologists of that day, as it was the first member of the genus known in which the inflorescence was not borne at the apex of the leafy stem. In this species, as well as in several others, the inflorescence is borne upon a leafless stem arising from the base of the leafy pseudobulb.

Mr. Skinner remarks (Batem. Orch. Mex. & Guat. *l. c.*) that the plant is known in its native country as "quartorones," in allusion to the four colors of its blossoms. The flowers of the plants which have blossomed in the New York Botanical Garden have undergone remarkable changes in color as they faded, the white of the lip passing into yellow and buff, and various combinations of these, produced by stripes, spots and blendings.

Elleanthus caricoides sp. nov. (PLATE 7)

A densely tufted plant, smooth and glabrous with the exceptions noted below, with numerous gracefully drooping slender stems. Stems 4 dm. long or less, round, about 1.5 mm. in diameter at the base, sparsely spotted with purple: leaves 5–7; sheaths grooved, much shorter than the blades, spotted with purple, the lower 2 or sometimes 3 soon turning brown, bladeless or with but rudimentary blades; blades flat, about 7-nerved, erect, somewhat twisted and recurved above the base, linear-lanceolate to linear, shining, long-acuminate at the apex, narrowed toward the base, 1–2 dm. long, the lowermost sometimes a little shorter and the one immediately below the inflorescence often but 4–6 cm. long, 7–8 mm. wide: inflorescence 2–3 cm. long, on a peduncle less than 1.5 cm. long, the bracts, the lowermost one of which is usually empty, ovate-lanceolate, green, apparently spirally arranged, long-acuminate, 2–3 times as long as the flower, nearly erect and somewhat recurved above the middle; flowers, including the ovary which is 2–3 mm. long and more or less appressed-pubescent with black-brown hairs, about 1 cm. long, gibbous on one side: lateral sepals 7–8 mm. long, about 3 mm. wide, oblong to oblong-oval, rather abruptly contracted above into a laterally compressed and keeled apex, more or less pubescent on the back with black-brown deciduous hairs, about 5-nerved; dorsal sepal 5–6 mm. long, and about 2 mm. wide, the compressed apex much less prominent: petals oblong-linear, somewhat dilated at the rounded and apiculate apex, 6–7 mm. long, 1.5–2 mm. wide: lip nearly campanulate, completely surrounding the column so that its margins meet, about 7–8 mm. long, when spread out 10–12 mm. wide at the truncate and sparingly ciliate apex and 5–6 mm. wide at the base, a 2-ridged crest just below the middle, the two appendages near the base of the lip oblong, papillate, 1.5–2 mm. long and about 1 mm. wide: column 7–8 mm. long, 4-toothed at the broadened apex.

On the lower horizontal branch of a tree bordering the Agua Caliente, in the humid region, upon the Finca Navarro, *no. 692*.

CATASETUM MACULATUM Kunth, Syn. Pl. Aequin. 1: 331. 1822

Cultivated at San José, *no. 352*. Another species which Mr. Maxon secured from Mr. Biolley, who secured it at San Mateo, on the Pacific coast. It flowered with us first on November 23 of last year. This material very closely agrees with the description of Kunth, also with the details of the figure published (H. B. K. Nov. Gen. & Sp. 7: *pl. 630*). The parts are not so green as called for in that description, and this perhaps accounts for Mr. Maxon receiving the plant under the name of var. *luteopurpurata* Cogn., a name, however, of which I can find no record of publication. Mr. Percy Wilson, who visited Honduras in 1903 in the interests of the New York Botanical Garden, also obtained living material of the same species which has flowered at the Garden.

Catesetum maculatum was found first near Turbaco, Colombia, at an altitude of about 324 m. I cannot think, however, that the *C. maculatum* of Bateman (Orch. Mex. & Guat. *pl. 2*) is the same thing, for the setae of the column are described and figured as very short, quite different from the very long ones in the true *C. maculatum* Kunth. The *C. maculatum* of Lindley (Bot. Reg. **26**: *pl. 62*. 1840) seems to be different also; the color of the flowers is quite different and the petals are entire, while in the plants from Costa Rica and Honduras these parts are decidedly serrated, thus agreeing with the original description of Kunth.

CYCNOCHES ROSSIANUM Rolfe, Gard. Chron. 69: 456. 1891

On tree-trunk at border of forest, vicinity of Rio Reventazon, Turrialba, *no. 172.* A most interesting find. Rolfe drew his description from material secured from a plant which flowered in the collection of Signor H. J. Ross, Poggio Gherardo, Florence, Italy, in 1889. This plant was purchased for *C. Warscewiczii*, quite another species with pure green staminate flowers, represented by a living plant in the collections of the New York Botanical Garden. The native country of the original plant of *Cycnoches Rossianum* was not known, and it is interesting to have its home thus revealed. The plants which Mr. Maxon brought back with him have produced up to the present time only staminate flowers, which agree with the description given by Mr. Rolfe.

The staminate racemes are long and slender, in the Costa Rican plant measuring up to 6 dm. long with the flowers rather scattered. The sepals and petals are yellowish-green, heavily blotched with purple-brown, as described by Rolfe, who says further that the pistillate raceme he examined had but a single flower which was about twice the size of the staminate flowers and of a uniform green color with a slightly darker shade on the lip.

XYLOBIUM FOVEATUM (Lindl.) Stein, Orchideenb. 597. 1892

Navarro, *no. 674.* This was originally described from plants secured in Demerara. Cogniaux (Mart. Fl. Bras. 3^6: 470) gives its range as extending to Venezuela, Peru and Colombia. While the Costa Rican material differs somewhat from the South American plant, judging from descriptions, it seems best for the present to refer it to the same species.

Maxillaria Valenzuelana (A. Rich.)

Pleurothallis Valenzuelana A. Rich. in Sagra, Hist. Cuba **11**: 234 1850.

Dicrypta iridifolia Batem.; Loud. Hort. Brit. Sec. Add. Suppl. 630. 1839. Name only.

Maxillaria iridifolia Reichenb. f. Bonplandia **2**: 16. 1854.

On tree trunk, Cartago, *no. 53.* Cogniaux (Mart. Fl. Bras. 3^6: 78) gives the distribution of this plant as extending from Brazil to Colombia and Cuba. Its discovery in Costa Rica therefore extends the range to the continent of North America.

As indicated above in the synonymy, the first name applied to this plant is a nomen nudum ; the origin of the plant was attributed to Trinidad. The first adequately published name seems to have been *Pleurothallis Valenzuelana*, described from Vuelta de Abajo, western Cuba. Reichenbach, *l. c.*, states that his plant came from Cuhobas, Cuba, and indicates that it was collected by Pöppig. Pöppig employed his time as a botanical collector and physician, his botanical activities being principally confined to Matanzas and S. Elena, near Cahoba and the territory to the south and the southwest (Urban, Symb. Ant. 1 : 130). The type locality of this plant is, therefore, whether one adopt the name of Richard or that of Reichenbach, western Cuba.

Zygostates costaricensis sp. nov. (PLATE 8)

Plant grayish-green. Stem very short : leaves grayish-green ; lower ones widely spreading, the upper ones ascending to erect ; sheaths equitant, 1–2 cm. long, their margins hyaline ; blades articulated to the sheath, inequilaterally lanceolate or oblong-lanceolate, sometimes slightly falcate, acute, laterally compressed, 1.5–4 cm. long, 4–10 mm. wide : inflorescence axillary, racemose, the rachis densely hispid with spreading hairs of variable length, the spreading bracts, both those at the base of the rachis and those subtending flowers, broadly ovate to orbicular, acute, about 2 mm. long, partly clasping the rachis, ciliate on the margin with glandular hairs : flowers not crowded, on hispid pedicels which are shorter than the bracts : sepals free, orbicular, wing-keeled on the back, about 2 mm. in diameter, obtuse, the keel ciliate with a few teeth, the body of the sepals on the back sparingly hispid : petals orbicular, about 2 mm. long including the short claw, keeled and sparingly hispid on the back : lip papillose, incurved and arching over the flower, concave, 4–5 mm. long when straightened out, green at the base, slightly dilated above where it is about 1 mm. wide when spread out, acute at the apex : the 2 appendages about 1 mm. long, spreading like a ram's horns, white, papillose, flattened, somewhat dilated toward the obtuse apex : column very slender and weak, bent back, geniculate, the rostellum with a long crooked beak which is recurved into a semicircle about the middle : anther of the general shape of the rostellum and somewhat exceeding it in length, and with a recurved tip : pollinia 4, on a long slender stipe which is bent back upon itself toward the apex.

On tree-trunk in forest, Finca Navarro, *no. 680*. The most interesting plant revealed thus far in Mr. Maxon's collections.

The herbarium material of this plant brought back still had the old racemes attached, but all the flowers were missing, so it was impossible to place it satisfactorily. Fortunately Mr. Maxon succeeded in securing some good living plants. These throve and came into flower in October of last year. This supplied the needed material for a definite determination of the plant. It was interesting to find that it belonged to the genus *Zygostates*, known hitherto only from Brazil and Paraguay, and that it was also an undescribed species. Another genus is thus added to the orchid flora of North America.

Zygostates is closely related to *Ornithocephalus*, which ranges from northern South America and Trinidad through Panama and Central America, with one or two outlying species in Asia and Australia. It is distinguished from *Ornithocephalus* by the two appendages near the base of the column. The structure of the column and the unusual lip of this Costa Rican member of the genus differ considerably from the same organs in other species of the genus, but it seems best, at least for the present, to refer it here.

WARSCEWICZELLA WENDLANDII DISCOLOR Reichenb. f. in Warn. & Will. Orch. Alb. 3: *pl. 126.* 1884

On trees in humid forest, Santiago, *no. 105;* on tree-trunk, Cartago, *no. 55*. This interesting color-variation, in which the sepals and petals are pale-green instead of white, was first noted in a plant that flowered in the collection of Mr. A. H. Smee, in England. It is a very desirable plant, as it flowers freely, and for a long period. The contrast of the lavender of the lip with the pale-green petals and sepals is most effective. It also has the added value of a pleasant perfume.

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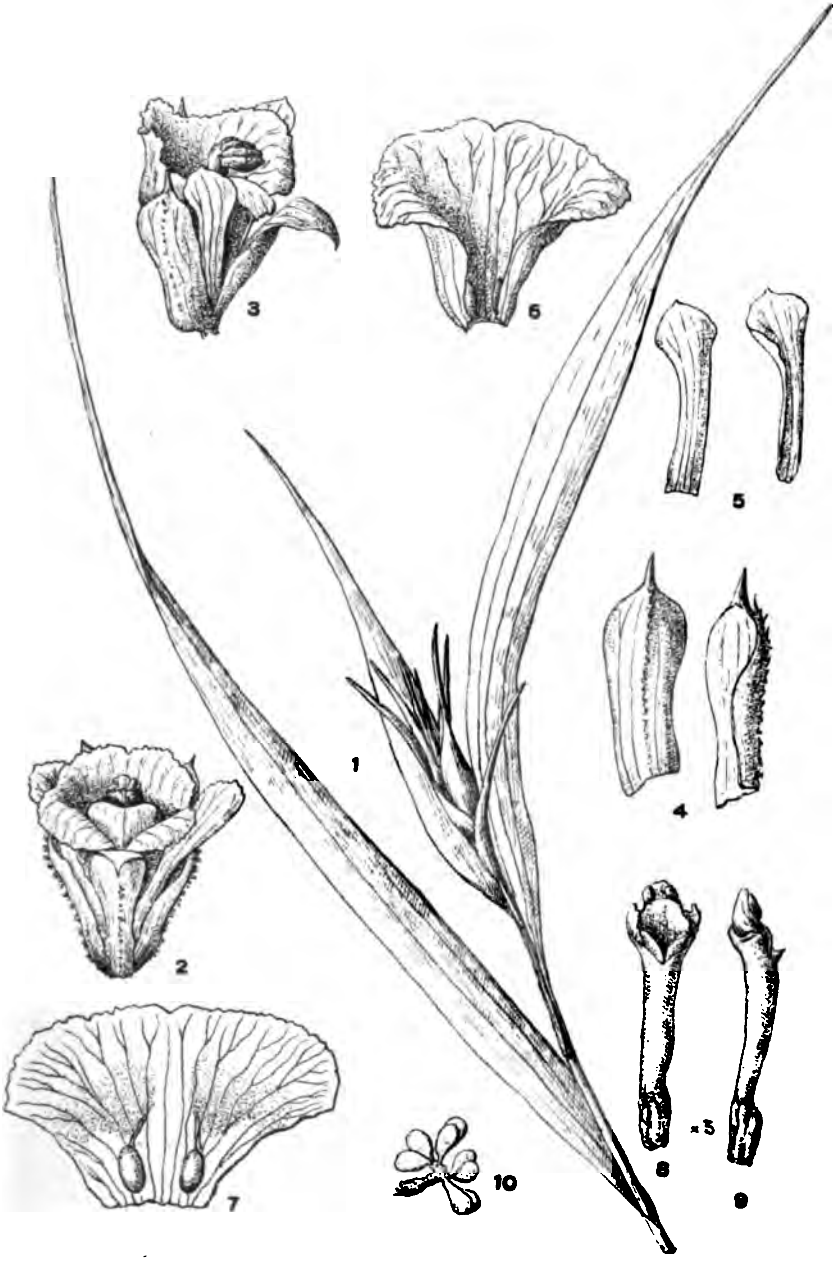
Explanation of plates 7 and 8

PLATE 7. ELLEANTHUS CARICOIDES Nash

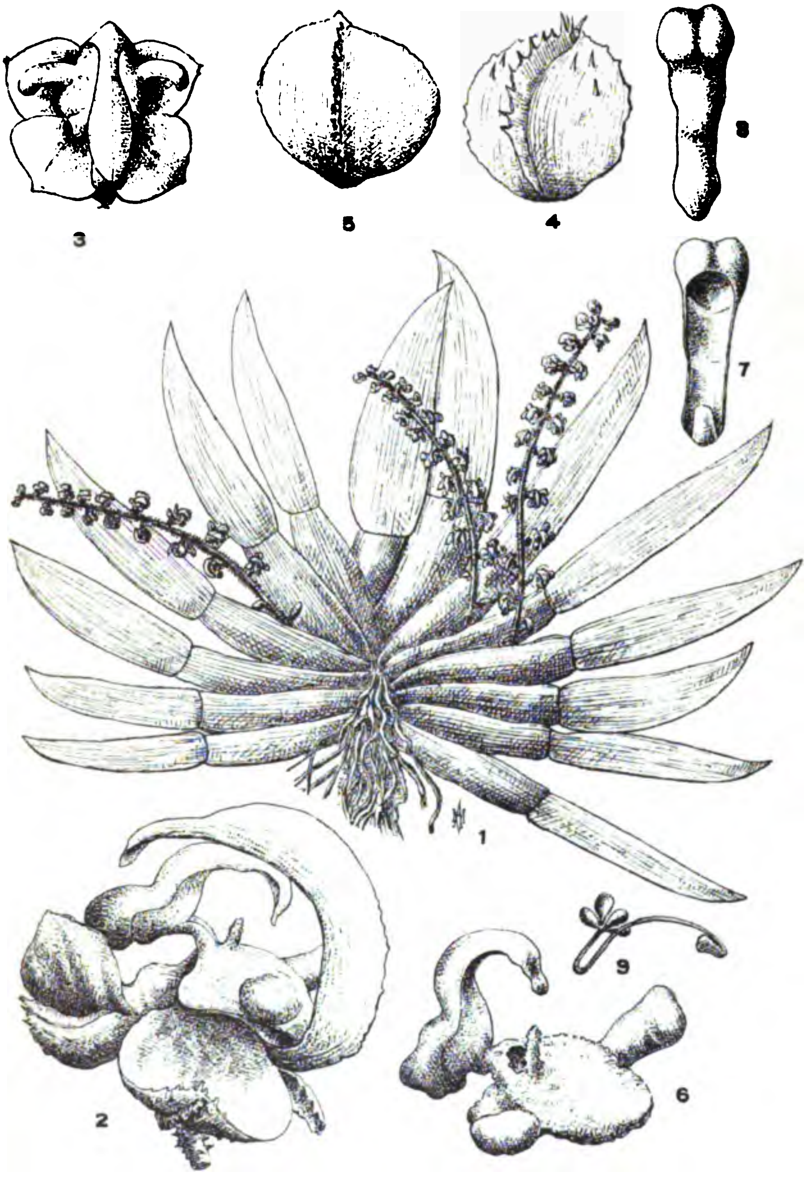
1. Apex of stem, natural size. 2. Flower, dorsal view, × 3. 3. Flower, lateral view, × 3. 4. Sepals, × 3. 5. Petals, × 3. 6. Lip, × 3. 7. Lip, spread out, × 3. 8. Column, anterior view, × 3. 9. Column, lateral view, × 3. 10. Pollinia, × 8.

PLATE 8. ZYGOSTATES COSTARICENSIS Nash

1. Plant, natural size. 2. Flower, lateral view, × 16. 3. Flower, from above, × 8. 4. Sepal, × 16. 5. Petal, × 16. 6. Appendages, column and anther, × 16. Anther, from below, × 16. 8. Anther, from above, × 16. 9. Pollinia, × 16.



ELLEANTHUS CARICOIDES Nash.



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AN OCCURRENCE OF GLANDS IN THE EMBRYO OF ZEA MAYS

BY C. STUART GAGER

NEW YORK
1907

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 125–137, *pl. 9.* 1907]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 34 : 125–137. 1907.]

An occurrence of glands in the embryo of Zea Mays

CHARLES STUART GAGER

The embryo of the grasses is an ancient battle-ground. Controversies over the homology of its various parts, and over their several functions, have been waged almost continually since the last half of the seventeenth century, when Malpighi[6] first described its anatomy. Its study formed part of the basis on which Schleiden[9] and Schacht[8] concluded that plant embryos originate in the end of the pollen-tube, while the embryo-sac serves only to protect and nourish them. By its study, in part, Mirbel and Spach,[7] and Brongniart[1] were led, on the other hand, to a diametrically opposite conclusion, namely, that the embryo originates in the embryo-sac, and that only after fecundation by the pollen.

The battle has waged fiercely over the indentification of the true cotyledon. The term scutellum (little shield), merely descriptive, harks back to Gaertner,[3] in 1788. His studies on the fruits and seeds of plants were considerably colored by his investigations of the eggs of animals, and he interpreted the shield-shaped organ in the grass embryo to be analogous to the vitellus, or nutritive part, of the animal egg. Hence he referred to it as "*vitellus scutelliformis*," or, briefly, *scutellum*. That he recognized it as really homologous with the cotyledon in other families is evidenced by the term "*scutellum cotyledoneum*" which he also employed.*

The literature shows some diversity in the significance with which the term scutellum is employed. Most authors use it, as Gaertner originally did, to apply to the entire organ, but at times its meaning has been narrowed† to the outer layer of cells, or epithelium of the shield. There seems to be little warrant and small gain in this latter restriction of it use, and the practice should be discouraged.

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* "Singularem hanc Vitelli speciem, proprio *Scutelli cotyledonei* nomine distinguimus." Gaertner[3] (page cxlix).

† Brown and Herron. Jour. Chem. Soc. Lond. Trans. 35 : 623. 1879.

A discussion of the various interpretations that have been given since the time of Gaertner as to the homology of its parts, would not be germane to this paper.* Goebel,[4,5] in 1895 and 1900 on the basis of Bruns's[2] work and of his own study of *Streptochaeta*, interprets it as a true cotyledon, while "the epiblast, which lies over against it, but is not present in all grasses, is an arrested leaf," and the coleoptile, or sheath of the plumule, is the third leaf. The first green leaf is the fourth leaf of the plant. Thus the view most generally held at the present time closely agrees with that put forward by Malpighi in 1675.

Questions of function have been fully as puzzling as those of structure, if not more so, and this, too, notwithstanding the opportunities for solution by the method of experiment.

As early as 1845, Schleiden[53] regarded the scutellum of the oat as an organ of absorption, and was followed in this view by Schacht[52] and Sachs.[48,49] It was Sachs who first pointed out the fact that the embryo, in its earlier stages of development, lives as a parasite on the endosperm, and we owe to him the term "absorptive epithelium," as applied to the outer layer of cells of the scutellum.

Three principal regions are concerned in the nourishing of the germinating embryo. These are the scutellar epithelium, the aleurone layer, and the remaining cells of the endosperm.

Dutrochet had shown that starch, as such, could not pass through semi-permeable membranes, like the cell-walls of plants, by osmosis, and thus the conclusion was forced that the food stored in the endosperm must be transformed before it could become available to the awakened embryo.

The earliest idea to develop in this connection was that the effective agent in this transformation was gluten. Fabroni, in 1785, is said † to have isolated from grape-juice a gluten-like, adhesive matter, without which fermentation did not take place. Thenard,† experimenting with several fruits, confirmed Fabroni's experiment, and considered the glutinous matter, isolated by filtering fruit juices, as identical with yeast. Thus the attention of chemists and physiologists was naturally directed to gluten as indicated above.

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* The different theories have been discussed by Van Tieghem.[10,11,12]

† Cited by Thomson[55] (1818), page 291.

In the same year (1785), Irvine[30] pointed out the fact that, in malting, not only did the malt become sweet, but the endosperm of crushed seeds, when mixed with the malt, also became converted into sugar.

Further advance seemed to await the discovery, by Colin and Claubry,[19] in 1814, that starch is colored blue by iodine.* This discovery became a great aid in endosperm studies.

In the following year Kirchhoff,[31, 32] on the basis of his experiments, concluded that the gluten accomplishes the formation of sugar in germinating seeds, and in farina that has been scalded with hot water. He also stated that the gluten attains through germination the property of transforming into sugar a much greater quantity of starch than is to be found in the seeds, and further clearly saw that the production of sugar in germinating seeds is a chemical process, and not a consequence of vegetation.

Experiments of a similar nature to those of Kirchhoff led Thomson,[55] in 1818, to the extreme view that the essential constituent of yeast is "a species of gluten," and "that it is some substance connected with the gluten that acts upon the starch, and converts it into sugar.

The studies of Proust[43] and of Saussure,[50] in 1819, and of Dombasle,[20] in 1820, on the conversion of starch to sugar by the action of gluten, contributed only slightly to the solution of the real question; but thirteen years later, in 1833, Biot and Persoz[13] announced the discovery of dextrine, which they had produced from starch by the influence of acids.† Vogel,[58] by similar means, had, in 1812, produced what was probably the same substance, but its name and the recognition of its true nature must be attributed to Biot and Persoz.

Previous to this, Braconnot,[15] in 1824, isolated a "special principle" which changed to sugar the starch from tubers of *Helianthus tuberosus*, and in the same year in which dextrine was discovered, Saussure[51] isolated from wheat endosperm a substance similar to Braconnot's "special principle," and which alone could convert into sugar four times its weight of starch. These studies, and that of Payen,[35] in 1824, paved the way for the discovery of diastase by Payen and Persoz[38] in 1833. This substance, its discoverers announced, could convert into dextrine 2,000 times its own weight of starch.

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* Scholz (Jour. für Chem. und Phys. 12: 349. 1814. Footnote) attributes this discovery to Stromeyer, but gives no citation.

† Raspail,[46] who discovered the mark, or "hilum" on starch-grains, stated his belief in 1826, that "the carbonic-acid of the air is sufficient to effect the transformation of starch to sugar" (page 335).

Later (1843, 1846) Payen[36, 37] demonstrated that starch must be altered "by water and diastase" before it can pass through cell-walls, and that only after being thus altered can it pass from tissue to tissue. The question now became, What is the source of the diastase by which, in germination, the endosperm is digested?

Raspail[45] had shown, in 1825, that, in germination, the endosperm gradually lost its starch, while the enlarging embryo became gradually enriched with starch-grains, and, in 1862, Sachs[48] observed that, in the germination of grass-embryos, the change of starch to sugar "begins on the side of the endosperm which lies next to the absorbing scutellum." He also demonstrated that the products of the solution of the endosperm are translocated to the germ, and homologized the scutellar epithelium "with the organ of the same name on the cotyledons of palms, and with the young epidermis of the *Ricinus* cotyledon . . . ."

From this time on, beginning with Bloziszewski,[14] in 1875, there have followed a number of researches on the germination of grass embryos deprived of endosperm, and on the ability of isolated embryos to utilize artificial endosperm. Among the earlier and more extensive of these investigations, are those of Brown and Morris,[16, 17] who demonstrated in 1888 the possibility of growing grass embryos on artificial endosperm, and, in 1890, showed that, at the beginning of germination, starch first reappears in the cells of the scutellum immediately under the epithelium. Its first appearance here, being coincident with the earliest stages of the depletion of the endosperm, was taken as evidence that it came from the latter.

The fundamental investigations as to whether or not the diastase could diffuse through cell-walls and, therefore, would not necessarily have to be secreted by the cells where it is to act, was not made until 1894, when Grüss,[23] with results contrary to those of Krabbe,[33] in 1890, demonstrated the possibility of such diffusion.

The work of Grüss indicated that the statement of Brown and Morris (1890), "that the disappearance of the cell-wall always precedes any visible attack upon the contained starch granules," is not true in all cases.

It would lead too far afield to review in detail the subsequent literature upon this topic. Experimental researches have led to at least five different views as to the place of origin of the digestive ferment during the germination of grasses. They may be briefly summarized as follows:

1. *The cells of the aleurone layer chiefly secrete the diastase,* which acts on the starch in the endosperm. This is the statement, in a more modern terminology, of the old view that starch is turned to sugar by gluten. It was tacitly assumed by Tschirch,[57] in 1889 (page 181, legend of *f. 63*).*

2. *The epithelium of the scutellum is the principal secreting layer.* This is the view of Brown and Morris,[16] in 1890,† of Grüss,[22] in 1893 (page 291), and, by implication, of Reed,[47] in 1904. According to Brown and Morris, a diastase that dissolves cell-walls is also secreted by these cells.

3. *The endosperm is the main source of the ferment,* according to Green[21] (1890), Krabbe[33] (1890), and Linz[34] (1896). "The diastase," says Krabbe, "is generally not translocated, but develops directly at the place of its activity." Secretion by the endosperm results "in consequence of some kind of stimulus on the part of the seedling." This last assertion was contradicted by Pfeffer[39] in 1893. Linz[34] definitely states (page 301), "that the epithelium of the scutellum of the seed of maize is not in a condition to secrete ferment, [and] that the epithelium is rather an apparatus which serves for the absorption of dissolved nutriment." Further on (page 318) he says, "The aleurone layer is not the source of the diastase which appears in the endosperm during germination."

4. *The scutellum and the endosperm secrete diastase,* but not so

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* The notion that pure gluten can change starch to sugar is now, of course, demonstrably erroneous, but whether or not the cells of the gluten- or aleurone-layer in the grass-fruit can secrete a diastatic ferment is a different question.

† Brown and Escombe[18] (page 14) demonstrate the hydrolytic capacity of aleurone-cells of barley, the capacity of this layer for endosperm depletion, and that such capacity on the part of the endosperm-cells is very probable.

the aleurone layer. This view is stated by Pfeffer,[40] in 1900, (page 599), who calls the diastase secreted by the scutellum "accessory diastase," and says its secretion may always be regulated by the needs of the plant. This conclusion is based in part upon the experimental demonstration that isolated bits of endosperm placed in contact with water become spontaneously depleted. In these experiments, the disappearance of the starch proceeds centripetally from the surface of the endosperm in contact with the water.

5. *All storage tissues are capable of auto-depletion*, according to Puriewitsch.[44] This conclusion was based upon studies of the endosperm and cotyledons of various seeds, and the contents of roots, bulbs, rhizomes, tubers, and other stems. In 1896 Grüss[25] states that "It is well known that the endosperm cells themselves secrete a ferment during germination" (pages 408, 422). This, together with his paper of 1895, indicates that his position then should be classed here, but in 1897 (page 664) he says: "Seedlings from which one has taken the endosperm may, without the aid of bacteria, nourish themselves upon starch paste, which thereby becomes changed to sugar." This, however, does not necessarily imply a change from his preceding position.

In addition to the above views, may be mentioned that of Wigand,[59] who in 1888, attributed a diastatic function to the aleurone layer, but only through the mediation of bacteria developing in it; and Hansteen's,[29] founded upon extensive though insufficiently guarded experiments, that it is not necessary for diastase to proceed from the scutellum during germination.

In 1890, Haberlandt[26] stated (page 48) that "The aleurone layer of the grass-endosperm, and presumably also of seeds of other plants, is henceforth to be classed with the digestive glands of insectivorous plants," and in 1904 he states (page 477) that "its histological structure, in connection with the experimental fact that the isolated gluten layer richly secretes diastase, forms the ground for my notion concerning the function of that layer." It is interesting to note that, in this last mentioned work, the pendulum has swung back to the original idea, advanced by Kirchhoff ninety years previously, that in germinating seeds the gluten is a source of the agent that changes starch to sugar. It hardly seems probable that Haberlandt's view will finally stand.

The work of Brown and Morris indicates that the endosperm of the grass fruit is dead, but the only inference warranted by the papers of Green, Krabbe, Hansteen, Pfeffer, and Linz is, as Linz definitely states (page 312), that it is alive.

The most obvious conclusion to be drawn from this review of the literature is that there is still need for further careful experimental investigation of the subject, in which every precaution shall be used to exclude bacterial contamination, and other sources of error. Such work has been done with the date seed by Pond,[42] whose experiments seem to leave little doubt that the date-endosperm, at least, is incapable of self-digestion.*

The facts of teratology have frequently thrown light upon normal structure, helping to establish the homology of an organ whose interpretation would otherwise remain in doubt. From the fact that structure is an expression of function, anatomical variations in the direction of a structure whose rôle is well understood, may quite justifiably be taken, in connection, of course, with other facts, as evidence of the probable function of the part that varies. It was with considerable interest, therefore, in the light of our present knowledge of the homology and physiology of the parts of the fruit of the *Gramineae*, that the writer, in an examination of cross-sections of the corn grain, observed a variation in the scutellar epithelium, the significance of which can scarcely be questioned.

This tissue, one cell thick, and variously called the "absorptive epithelium" and the "glandular epithelium," is, as is well known, clearly defined anatomically from the adjacent tissue on either side. The shape of its cells, narrow and oblong in section, their palisade arrangement, and the appearance of the protoplasm, granular and relatively dense in the resting seed, more vacuolated as germination begins, and with a well defined, vigorous nucleus, clearly distinguish it. Normally it forms an unbroken layer over the convex surface of the scutellum.

In the sections examined, this layer was found invaginated in places, in such a way as to form small pockets or sacs in the tissue of the scutellum. On one side there were two such structures, and on the other side one, with a slight suggestion of an unfinished fourth. The diagram (FIGURE I), shows the location of these structures in the scutellum, while they are shown in detail in the photomicrographs, FIGURES 2 and 3. Two of them, as may be seen in the diagram, are of practically uniform diameter throughout, while the other and larger one is enlarged at the end.

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* A conclusion contrary to that reached by the same author[41] in 1904, when there was failure to observe certain necessary precautions of method.

Describing the scutellum of the corn in 1902, Torrey[56] says: "At the region of the tip this secretory epithelial layer dips down at frequent intervals into the scutellum. The convolutions so produced secure a larger surface of secretion where there is greatest need for the enzyme; for the endosperm is thickest at this point and in front of the embryo." Whether the structures seen by Torrey were the same as those described above is not entirely clear from his description, but his figure (*f. 1*) indicates that they were at least very similar. If so, their location is not restricted "to the region of the tip" of the scutellum, as is clearly shown in FIGURE I herewith. Thus their distribution does not seem to be correlated with the thickness of the endosperm.

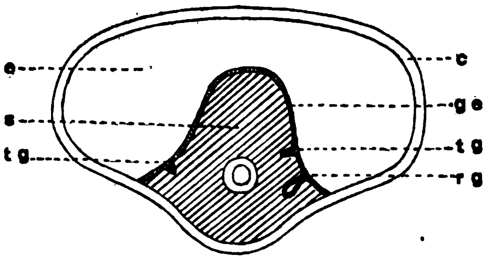

FIG. I. Diagram of cross-section of grain of *Zea Mays*. *c*, combined coats of fruit and seed; *e*, endosperm region; *s*, scutellum; *ge*, glardular epithelium; *tg*, tubular glands; *rg*, gland slightly racemose.

What is their significance? The variety of the corn is the "Hickory King," of J. M. Thorburn & Co., and the grains are of uniformly large area, though relatively flat and thin. Because of these facts it may be suggested, not unreasonably, that this invagination of the epithelium is merely an expression of vigorous, rapid growth, without corresponding opportunity for expansion. An analogy is found in the uneven, crinkled surface of foliage-leaves in many plants, due to the fact that one epithelium has grown more rapidly than the other. The wrinkling is a "mechanical necessity." This suggestion, I think, may be dismissed at once as having too little warrant in the facts, and as being less probable than another.

If the scutellar epithelium is primarily an organ for the absorption of nutriment, as Sachs held, the variation described would be even more surprising, for we should reasonably expect an evagination, or haustorial-like projection of the tissue into the endosperm, rather than an invagination, especially if the conception of the intimate relation between structure and function is valid.

If, however, we have to deal here with an epithelium whose chief function is secretion, then the variation described is one that might have been predicted, and when once seen, the greater surprise would be that it was not of more frequent occurence. The first impression, that the anomalous structures are glands, is only strengthened by more careful observation and more thoughtful consideration. Any anatomist would at once classify the smaller invaginations as tubular glands, the simplest secreting structure next to the glandular epithelium, while the larger sac more nearly resembles a simple racemose gland.

Figure 2

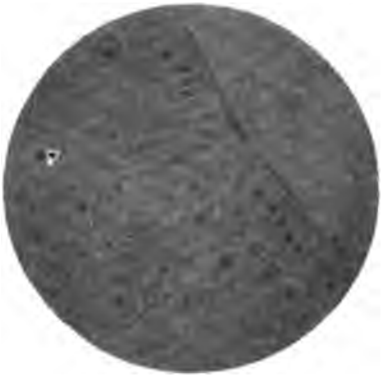

Figure 3

Fig. 2. Photomicrograph of cross-section of grain of maize. Tissue of scutellum at left, tissue of endosperm at right. Showing two glands in the scutellum.

Fig. 3. Photomicrograph of the upper gland of figure 2, more highly magnified.

Evidence of secretory activity was not sufficient in any part of the sections to throw light on the function of these structures. Their function may be inferred only from their anatomy, in the light of other well-known physiological observations.

Obviously no inference may be drawn from this anomaly as to the normal or the possible functions of the endosperm cells, nor of the cells of the aleurone layer, nor may any definite conclusion be drawn, on this basis alone, as to the proper function of the tissue involved. The weight of the evidence, however, is in line with all the facts of anatomy and experimental physiology which indicate that the scutellar epithelium of the grass embryo is an organ of secretion, a true glandular epithelium.

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CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
GARDEN—No. 93

AMERICAN FOSSIL MOSSES

WITH DESCRIPTION OF A NEW SPECIES FROM FLORISSANT, COLORADO

BY ELIZABETH G. BRITTON AND ARTHUR HOLLICK

NEW YORK
1907

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 139-142, *pl. 9.* 1907]

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 139–142, *pl. 9.* 1907]

American fossil mosses, with description of a new species from Florissant, Colorado

ELIZABETH GERTRUDE BRITTON AND ARTHUR HOLLICK

(WITH PLATE 9)

During the summer of 1906 Professor Theo. D. A. Cockerell and his wife spent several weeks at Florissant, Colorado, collecting fossil plants. Among those collected was found a beautifully preserved fruiting tuft of a moss, which was kindly transmitted to us for examination and description. The specimen was obtained from the well-known Tertiary shales of that locality, from which quantities of fossil insect and plant remains have been secured by many different collectors from time to time; but among the thousands of specimens thus brought to light only three have been heretofore described as mosses, viz.

Hypnum Haydenii Lesq. Ann. Rept. U. S. Geol. and Geog. Surv. Terr. 1874: 309. 1876; Bull. U. S. Geol. and Geog. Surv. 1: 583. "1875" [1876]; Rept. U. S. Geol. Surv. Terr. 7 (Tert. Fl.): 44. *pl. 5. f. 14, 14a, 14b.* 1878. (PLATE 9, FIGURES 1, 1a.)

Fontinalis pristina Lesq. Rept. U. S. Geol. Surv. Terr. 8 (Cret. and Tert. Fl.): 135. *pl. 21. f. 9.* 1883. (PLATE 9, FIGURES 2, 2a.)

Hypnum Brownii Kirchner, Trans. Acad. Sci. St. Louis 8: 178. *pl. 12. f. 4, 4a.* 1898. (PLATE 9, FIGURES 3, 3a.)

None of these, however, is a fruiting specimen, and the generic determinations were based entirely on the leaf-characters, which, even if well defined, would not in themselves be characters from which generic or even family relationships could be satisfactorily determined. In this connection it may be suggested that the species first mentioned is more indicative of a *Lycopodium* or a conifer than of a moss, and the author voices his uncertainty in acknowledging that "the apparently thick leaves seem abnormal for a species of moss," and that "the mode of division . . . separates it from the Lycopods." *

In regard to the second species cited it may be merely remarked that the correctness of its reference to the genus *Fontinalis* is questionable, so far as may be judged by the figures, while in regard to the one last mentioned the author, in his description, says: "The leaves in most cases are indistinct and only the more solid stems are discernible." It is apparently a moss, but satisfactory evidence of its relationship with the genus *Hypnum* is not apparent in the figures.

The only other American fossil-plant remains described as mosses, with the exception of several existing species from deposits of Pleistocene and more recent age, are *Hypnum columbianum* Penhallow, in Dawson, Trans. Roy. Soc. Canada 8^4: *77. fig. 3.* 1890 (PLATE 9, FIGURE 4), from lower Tertiary beds at Quesnel, B. C., which is more likely a conifer, apparently related to *Widdringtonia helvetica* Heer, Fl. Tert. Helv. **1**: 48. *pl. 16, f. 2–18*, or to *Glyptostrobus Ungeri* Heer, as depicted by several authors; and *Rhynchostegium Knowltoni* E. G. Britt., described and figured in Bull. Torrey Club **26**: 79, 80. 1899 (PLATE 9, FIGURE 5), from the upper Eocene or Miocene sandstone at Cle Elum, Kittitas County, Washington. These specimens, as in the case of those previously mentioned, are also sterile, so that in our specimen from Florissant we have the first fossil moss with fruit thus far recorded from America.

Glyphomitrium Cockerelleae sp. nov.

(PLATE 9, FIGURES 6, 6a)

Plants pulvinate, forming a dark-brown tuft 1 cm. high and 2.5 cm. wide, with lignitic remains appearing like a mass of dark-brown radicles. Stems erect and crowded, evidently branching: leaves

---

* Through the kindness of Dr. J. N. Rose, Associate Curator of the Division of Plants, U. S. National Museum, the type specimen of *Hypnum Haydenii* was transmitted to us for examination, from which our figures were made. We are satisfied that it is not a moss, and Dr. L. M. Underwood, of Columbia University, has expressed his opinion that it can not be a *Lycopodium*. The closest comparisons which we have been able to make are with certain conifers, especially with forms of *Juniperus communis* L., in which the young growing branchlets often present a striking similarity in general appearance to this specimen.

2–3 mm. long, linear-lanceolate, straight or curved, apparently with a thick vein and slender sharp apex: sporophytes terminal: seta erect and straight, 1–1.5 cm. long: calyptra mitrate and plicate, 2–2.5 mm. long, with well-marked ridges forming darker grooves in the light-colored stone.

The capsules were not yet developed when this specimen was buried and nothing but the calyptra remains to indicate the nature of the sporophyte, but from general aspect and characters it seems to belong nearest to the *Grimmiaceae* with a resemblance to the *Ptychomitrieae*, the calyptra being grooved and long, completely enclosing the sporophyte when young, as in *Ptychomitrium*, and prolonged into an acute apex as if the lid were rostrate.

This species is dedicated to Mrs. Wilmatte Porter Cockerell, in recognition of her devotion to science and her invaluable assistance in securing specimens from this locality.

This genus has been known in American bryological works as *Ptychomitrium*, but the older name has been reinstated by Brotherus in Engler & Prantl, Pflanzenfamilien (1³: 440. 1902) while keeping the name of the section, as indicated above. The synonymy is as follows:

Glyphomitrium Brid. Mant. 30. 1819; emend. Mitt. Jour. Linn. Soc. **12**: 105. 1869.
Brachysteleum Reichenb. Consp. 34. 1828.
Ptychomitrium (Bruch) Furnr. Flora 1829, Erg. 2: 19. 1829.
Notarisia Hampe, Linnaea **11**: 379. 1837.

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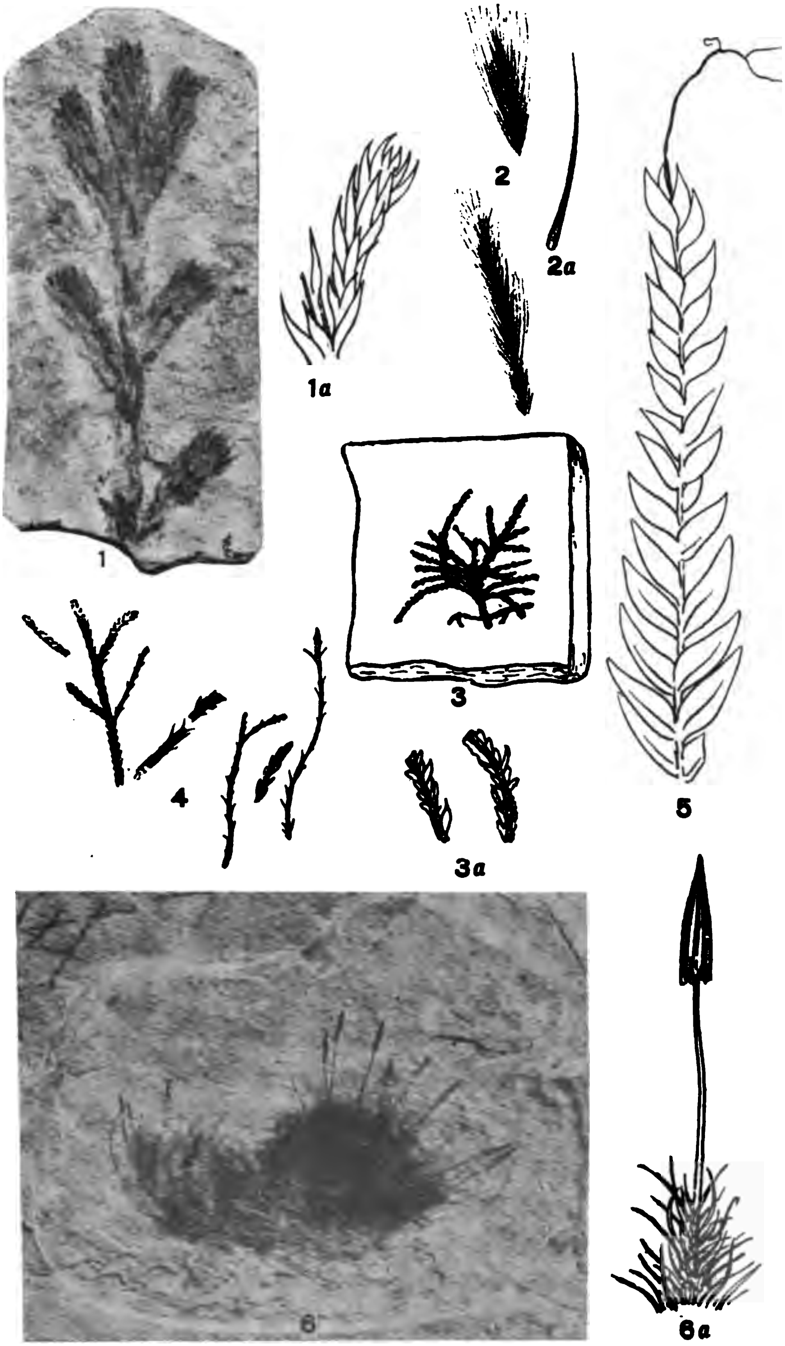
Explanation of plate 9

Figs. 1, 1*a* — *Hypnum Haydenii* Lesq.
  Fig. 1 × about 1⅗.
  Fig. 1*a* × about 2.
Figs. 2, 2*a* — *Fontinalis pristina* Lesq.
  Fig. 2 natural size.
  Fig. 2*a* × about 1½.
Figs. 3, 3*a* — *Hypnum Brownii* Kirchner.
  Fig. 3 natural size.
  Fig. 3*a* × about 5 (?).
Fig. 4 — *Hypnum columbianum* Penhallow. Natural size.
Fig. 5 — *Rhynchostegium Knowltoni* E. G. Britt. × about 9.
Figs. 6, 6*a* — *Glyphomitrium Cockerelleae* E. G. Britt. and Hollick
  Fig. 6 × about 1⅗.
  Fig. 6*a* × about 7.



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Solution Tension and Toxicity in Lipolysis

BY

RAYMOND H. POND

NEW YORK
1907

[*Reprinted from the* American Journal of Physiology, *July, 1907*]

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VOL. XIX. — JULY 1, 1907. — NO. II.

SOLUTION TENSION AND TOXICITY IN LIPOLYSIS.

BY RAYMOND H. POND.

[*From the Chemical Laboratory of the New York Botanical Gardens.*]

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INTRODUCTION

AN effort has been made to ascertain whether lipolysis is affected by toxic agents in a manner corresponding to that found by Mathews[1] for fertilized eggs of Fundulus, by McGuigan[2] for diastatic activity, and by Caldwell[1] for proteolytic digestion. Mathews announced as a general law that the toxic action of cations as such and of anions as such is an inverse function of, and is determined by, their solution tension. The toxic action of any salt is, then, an inverse function of the decomposition tension of that salt which is the sum of the solution tension of the cation and of the solution tension of the anion of that salt, both values being regarded as having the same sign.

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[1] MATHEWS, A. P.: American journal of physiology, 1904, x, pp. 290–323.

[2] MCGUIGAN, H.: American journal of physiology, 1904, x, pp. 444–451.

Solution tension is really the affinity of an ion for its charge, and may be measured and expressed in volts. Thus mercury, having a low solution tension, readily yields its charge to another substance, and hence is more potent in disturbing the organization of that substance than sodium, for example, which has a high solution tension and is consequently relatively inert toward such a substance. Disregarding for the present the exceptions observed by Mathews,[2] it may be noted that he based his law upon the fact that when the metals are arranged according to their solution tension they are also arranged in the order of their relative toxicity toward the eggs of Fundulus. The same general relation was found by McGuigan[3] and Caldwell,[4] as mentioned, and so far as I know the validity of the law has never been questioned.

It may be said that it is a matter of interpretation as to whether the experimental data gathered by any one or by all of those men warrants such a conclusion. If there were no exceptions (some were found in each research) and if the results of the three papers were in perfect agreement, would the evidence be conclusive for the law formulated? This is merely a matter of logic, and in another form the question is, When does circumstantial evidence constitute a demonstration? Since the work by those men seems inconclusive, I have attempted to remove existing doubt in the matter. In the catalytic saponification of esters we have a reaction which can be measured perhaps more accurately than any so far tested, and of course more satisfactorily than in the case of living organisms.

The original intention was to extract a lipase from the Castor Bean, and then to ascertain the effect of various salts upon the saponification of castor oil by this lipase. Comparative tests with a commercial product (Holadin) having lipolytic power revealed the fact that much sharper end points could be obtained when ethylbutyrate was saponified by this commercial product than when castor oil and lipase were used. It is much easier to obtain pure ethylbutyrate than pure castor oil. For those reasons the Holadin was used.

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[1] CALDWELL, S. J.: Botanical gazette, 1905, xxxix, pp. 409–419.

[2] MATHEWS: *Loc. cit.*

[3] McGUIGAN: *Loc. cit.*

[4] CALDWELL: *Loc. cit.*

All of the work here presented has been done in the laboratory of the New York Botanical Garden, and I am indebted to this institution for financial support and liberal encouragement in the investigation. To Professor Wm. J. Gies I wish to make special acknowledgment for frequent and valuable counsel.

METHODS.

Holadin. — This substance is a commercial product prepared from pancreatic glands by Fairchild Brothers & Foster of New York City. The lipolytic activity of this preparation is regarded as relatively less than its proteolytic or its amylolytic power. It comes to market as a powder which is very hygroscopic and soon decomposes with a strong odor if exposed. If kept in a properly stoppered container, the lipolytic efficiency remains undiminished for a period of six months, at least, this being the limit of my experience. On forming a colloidal solution with water the reaction is at once appreciably acid if the solution is sufficiently concentrated. If 2 c.c. of the filtrate obtained by filtering a colloidal solution containing 1 gm. of the powder in 100 c.c. of water be added to 2 c.c. of water, it is found that about 0.30 c.c. of M–20 KOH is required to neutralize the total volume of 4 c.c. After four hours' incubation at 40 C. this initial acidity will be doubled. To what the initial acidity is due, or why there is an increase during incubation or digestion at room temperature, is not known. Perhaps there is some fat or other acid-yielding substance in the powder. Boiling inhibits the progress of acid formation during incubation. The initial acidity of a solution of the concentration mentioned is not changed by boiling. In stronger solutions, however, there is possibly a slight increase in acidity due to boiling, but it is too slight to be accurately measured by M–20 KOH and is therefore negligible.

On heating a filtered solution of 1 gm. of the powder in 100 c.c. of water it is noted that coagulation commences at about 60° C. Heavy flocculation soon occurs at higher temperature. The filtrate of this boiled solution contains protein substance, and gives the reaction for phosphate with molybdic solution. Salts of the heavy metals will give precipitates upon addition to this filtrate. It is possible, however, to have a solution so dilute that there is no initial acidity, that acid formation will not occur during an incubation period of four hours, that the merest opalescence appears on boiling and yet the lipolytic activity of the unboiled solution is sufficient to produce from neutral ethylbutyrate during an incubation of four hours enough acid to require 0.20 c.c. of M–20 KOH for neutralization. Only salts of the heavy metals will precipitate anything from a solution of such concentration, though the incubation be prolonged to eighteen hours. We thus can have lipolytic activity under conditions which allow its determination with very pleasing accuracy.

An aqueous solution is prepared as follows: The weighed quantity of Holadin is triturated in a mortar with just enough water to form a paste. More water is then added, and thorough mixture is secured by merely rotary motion. If shaken, an abundant froth forms which greatly interferes with filtration. The efficiency of the solution is decreased by filtration, but accuracy requires a homogeneous colloidal condition. All samples were therefore filtered.

Solutions of toxic salts. — In order to determine the relative toxicity of the various salts with accuracy, it seemed desirable to have the same anion in as many cases as possible. The nitrates were selected. The nitrate of mercury decomposes with water to form an insoluble basic salt so that a substitution had to be made on this account. Just how this difficulty was met by Caldwell[1] is not understood as he records the use of both mercurous and mercuric nitrate. For this reason I used the chlorid of mercury instead, but with this exception all of the salts used were nitrates. Mathews[2] and McGuigan[3] used the chlorid of mercury in comparison with the nitrate of silver. Caldwell[4] states that "the nitrates uniformly inhibit the action of the enzyme (bromelin) in somewhat greater dilution than the corresponding sulfates and chlorides which agree closely." The chlorid of mercury is not, however, in his list, and this may still be an exception to the relation found by him. Kahlbaum's C. P. chemicals were used in all cases except that of lead, which was J. T. Baker's guaranteed purity. Weighings were made from new and original packages. Salts not carrying water of crystallization were regarded as anhydrous and weighed as such. The molecular weight of salts containing water of crystallization was calculated to include the water. No allowance was made for deliquescence during weighing. However the weighing was done as rapidly as possible. The deliquescent salts were all obtained in the crystalline form. Error due to deliquescence is negligible in view of the concentrations used. The molecular weights were based upon the international table of atomic weights with oxygen as sixteen. All the solutions were made up molecular, so that M–32 silver nitrate is equivalent with M–64 of barium nitrate. The actual values used are as follows:

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[1] CALDWELL: *Loc. cit.*

[2] MATHEWS: *Loc. cit.*

[3] MCGUIGAN: *Loc. cit.*

[4] CALDWELL: *Loc. cit.*, p. 415.

Nitrates.	Mol. weight.	Nitrates.	Mol. weight.
Ammonium	80.112	Magnesium + 6 water . .	256.536
Barium	261.480	Mercury (chlorid)	270.900
Cadmium + 4 water . .	308.544	Potassium	101.190
Cobalt + 6 water . . .	291.176	Silver	169.970
Copper + 3 water . .	241.728	Sodium	85.090
Lead	330.980	Strontium	211.680
Lithium	69.070	Zinc + 6 water	297.576

The use of ethylbutyrate. — This ester is suitable because it can be used pure. The butyric acid arising from its saponification readily dissolves in water containing the alcohol which forms simultaneously with the acid. Being lighter than water and only slightly miscible, it floats upon the surface so that the saponification products diffuse downward as rapidly as formed, leaving the residual butyrate exposed to the action of the enzyme. As obtained under the label "absolute," ethylbutyrate contains saponification products and has an acid reaction. A supply of pure and hence neutral butyrate was prepared and kept as follows: On shaking with water several times in a separatory funnel the acid and the alcohol can be removed. Further shaking with dilute alkali to which some litmus has been added completes the preparation. Thus a stoppered cylinder contains two separate liquids. The lower one is blue if alkalin, and the upper one, the butyrate, is clear, and may be regarded as neutral as long as the lower liquid separates blue after thorough shaking. If the container is carefully stoppered, the spontaneous saponification is not rapid, and by shaking each evening one can have each morning a supply of neutral butyrate which may be withdrawn with a pipette. Such a neutral butyrate will not develop an acid reaction in distilled water during an incubation of four hours at 40° C.

Titration with phenolthalin. — This indicator proved very satisfactory, and was used in every case except that of ammonium. The same amount of indicator was used in each titration (one drop from an expansion stopper). The amount of lipolytic activity was measured by the number of c.c. of M–20 KOH required to make the preparation neutral after digestion. Suitable controls were carried in each test and will be described. The indicator was of course added at the close of the incubation period.

Sources and control of error. — The control preparations were exactly like the others, except in one particular, namely, the enzyme solution used had been boiled over the free flame. Boiling was continued only a few seconds, as the activity is practically destroyed at a lower temperature. That this treatment was adequate is shown by the fact that the controls were neutral after digestion, which means that the butyrate was beyond doubt also neutral.

The individual digestive mixtures were made up in the following manner: Six were used for each concentration of the toxic agent, of which three were controls. To each vial were first added 2 c.c. of the toxic solution of a concentration twice as great as was intended for the test. Then to the three controls were added for each individual 2 c.c. of the *boiled* enzyme solution. Then to the other three individually were added 2 c.c. of the *unboiled* enzyme solution. A total volume of 4 c.c. was thus present in each individual of every test. Then, to each individual were added 0.10 c.c. of neutral butyrate. This order of procedure was strictly followed in every test. After the incubation the difference in acidity between the controls and the others as found by titration was attributed to the activity of the enzyme. In the concentration of the enzyme used there was no initial acidity, and the boiling left the reaction neutral, so there was no error from those sources. If the butyrate had happened to be slightly acid, the same amount would have been added to each vial. The butyrate was measured accurately from a 1 c.c. pipette graduated to one-hundredths. To ascertain the full activity of the enzyme a set of six mixtures was prepared, in which distilled water replaced the toxic agent.

Optimum conditions. — Since it seemed more important to eliminate disturbing factors than to provide conditions for the maximum activity of the enzyme, all of the tests were carried out with the reaction neutral. Some of the toxic solutions have an initial acidity as, for example, zinc nitrate M–64 is so acid that 3.40 c.c. of M–20 KOH are required to bring 4 c.c. of it to neutral reaction. In such cases the natural acidity of the reagent was not neutralized. It can hardly be assumed that the addition of acid or of alkali even in completely dissociated condition does not alter the toxicity of the reagent. Since the activity of the enzyme varies with acidity, with alkalinity, with temperature, etc., it is more important to maintain uniform conditions with disturbing factors reduced to a minimum than to establish certain optimum conditions with such factors present. The temperature of 40° C. was selected for all the experiments. The actual concentration of the enzyme was not known. The following was the procedure in the preparation of the colloidal solution of the enzyme. One tenth of a gram of the enzyme powder was triturated with a little water and diluted to 100 c.c. This was filtered from a small residue which was discarded with the filter. Of this filtrate 50 c.c. were diluted to 200 c.c. Then of this volume 2 c.c were pipetted to each vial which already contained 2 c.c. of the toxic agent or of distilled water. If all the powder had dissolved, and if the powder had been dry at the beginning, the concentration of the enzyme ready for incubation would have been 0.0125 per cent. It must, of course, have been less than that. The concentration of the enzyme solution, when boiled, was 0.025 per cent. There was no flocculation. After the incubation there was sediment in only one case, mercury.

RELATIVE TOXICITY WITH THE CONCENTRATIONS OF ENZYME THE SAME.

Sodium, lithium, and potassium in contemporaneous test. — The figures in the tables which follow express the quantity in c.c. of M-20 KOH required for the neutralization of the liquid in each individual vial at the close of the incubation period. If the acidity of the three individuals of a given group varied, the average was taken. If more than one was wrong, the test was repeated. As a rule only very trivial variation appeared. In the column headed "M" is given the concentration of the toxic salt, present during the incubation, in terms of fractional molecular concentration. Thus 64 in the column headed "M" means a concentration of one sixty-fourth molecular. The word "Water" in this column means that 2 c.c. of distilled water replaced the 2 c.c. of the toxic salt, so that the uninhibited activity of the enzyme is shown. The column headed "Reagent" shows the initial acidity of 4 c.c. of the toxic salt solution of the concentration indicated by the corresponding figures in the column headed "M." The column headed "Increase" shows the difference between the acidities of the control and of the enzyme solution at the close of the incubation period, and expresses the activity of the enzyme under the conditions tested for the concentration of the corresponding toxic solution indicated in the column headed "M." If one drop of alkali produced a deep purple, the acidity was called zero.

TABLE I.

SODIUM, LITHIUM, AND POTASSIUM.

M[1]	Reagent.[1]	Control.[1]	Enzyme.[1]	Increase.[1]
Water	....	0.00	0.20	0.20
64	0.00	0.00	0.20	0.20
32	0.00	0.00	0.15	0.15
16	0.00	0.00	0.10	0.10
8	0.00	0.00	0.07	0.07
4	0.00	0.00	0.03	0.03

Enzyme, 0.0125 per cent.[1] Incubation period, 4 hours. 40° C.

This test was repeated the following day with exactly the same result, so that the relative toxicity of these three nitrates is based upon the agreement of six individuals for each concentration of the toxic salt both for the controls and for the enzyme. The salts were neutral in all concentrations tested. The controls were all neutral after incubation, so it is evident that the butyrate added to the control must have been neutral at the beginning and did not perceptibly become saponified.

A concentration of M–4 does not totally inhibit, while in M–64 there is no inhibition at all, as is shown by the figure, for the enzyme in the absence of toxic agent. Since the same figures were obtained for all three salts in a contemporaneous test, it seems clear that they are practically equal in toxicity under the conditions tried. Since M–4 allows only 0.03, it is reasonably certain, though not proved, that M–2 is the approximate point of total inhibition. All the preparations were water clear after digestion and with no sediment whatever present; the end point was very sharp.

Barium, strontium, and magnesium in contemporaneous test. — It may be noted, by referring to Table I, that since all the controls were neutral and the reagents also neutral in the concentrations indicated, the figures for the column headed "Enzyme" are identical with the corresponding ones in the column headed "Increase." The same relation was found in this contemporaneous test of barium, strontium, and magnesium. To avoid repetition, the figures expressing "Increase" are alone indicated under the name of the corresponding metal.

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[1] See pages 263 and 264.

TABLE II.

BARIUM, STRONTIUM, AND MAGNESIUM.

M.	Barium.	Strontium.	Magnesium.
64	0.15	0.10	0.10
32	0.07	0.05	0.05
16	0.03	0.03	0.05
8	0.00	0.00	0.00
Water = 0.20			

Enzyme, 0.0125 per cent. Incubation period, 4 hours. 40° C.

All the preparations were water clear after digestion and free from sediment. Practically the same figures were obtained in a subsequent test. These three salts are undoubtedly, under these conditions, practically equal in toxicity.

The figure showing the uninhibited activity of the enzyme is identical with that obtained in the test given in Table I. In comparison with sodium, lithium, and potassium these three are certainly more toxic, and upon an equimolecular basis the ratio is 1 : 4 if the limit for the former is assumed to be M–2.

Ammonium. — Since phenolthalin cannot be used in the case of ammonium, liquid litmus was used instead, being added of course after the incubation. In other respects the conditions were exactly the same as in the preceding test. To avoid error due to change of indicator, the barium test was repeated at the same time. The litmus was used in the place of the phenolthalin. The titration with litmus is not sharp, as is the case with phenolthalin, but in this test it happened that the figures for barium corresponded exactly with those obtained in the preceding test, so that it is unnecessary to repeat them. This means that the result with litmus in this case is just as satisfactory as with phenolthalin, and the figures for ammonium are strictly comparable with those for barium and the rest. Since all the controls were neutral and the reagents were also neutral in all dilutions of the test, only the figures showing the acidity developed during incubation are given.

TABLE III.

AMMONIUM.

M.	Increase.
32	0.10
16	0.05
8	0.03
4	0.00
Water	0.20

Enzyme, 0.0125 per cent. Incubation period, 4 hours. 40° C.

The limit for ammonium is evidently at 4, and allowing for the fact that it is univalent makes it equal in toxicity with barium, strontium, and magnesium. All the preparations were water clear after digestion and free from sediment. On titration a precipitate did not appear at or near the neutral point, which is also true of the salts thus far tried, but is not true of some of those to be referred to presently.

Cadmium, cobalt, and zinc in contemporaneous test. — Since in higher concentrations the solutions of these salts are acid, it seemed necessary to know the actual acidity of the plain salt solution for each dilution tried. In the table, therefore, there is the column headed "Reagent," which shows the acidity of 4 c.c. of the toxic salt corresponding to the concentration indicated in the column headed "M." It may be noted, as might be expected, that the acidity increases directly with the concentration. The acidity of the control does not vary with such precision. In this test the incubation period was lengthened, so that digestion could be going on during the night to save time. This was regarded as safe, since the salts are toxic enough to prevent any bacterial action during the incubation. But even granting some fermentation, which is very improbable, it would be equally distributed in the control and in the enzyme solution.

All the preparations were water clear and free from sediment after the incubation. On titration with alkali a precipitate appeared at the neutral point, or in some cases shortly before. The concentration at which this precipitate first appeared agreed closely with that of the plain reagent showing the first trace of acidity. The plain reagent also throws down a precipitate at or nearly the same concentration. The coincidence of these points was closer, the greater the dilution of the enzyme.

TABLE IV.

M.	Reagent.	Control.	Enzyme.	Increase.
		CADMIUM.		
2048	0.00	0.00	0.20	0.20
1024	0.00	0.03	0.20	0.17
512	0.00	0.05	0.20	0.15
256	0.00	0.10	0.20	0.10
128	0.05	0.20	0.20	0.00*
64	0.10	0.30	0.30	0.00**
		COBALT.		
2048	0.00	0.10	0.20	0.10
1024	0.00	0.15	0.25	0.10
512	0.00	0.20	0.25	0.05*
256	0.02	0.25	0.30	0.05**
128	0.05	0.30	0.30	0.00***
		ZINC.		
2048	0.10	0.15	0.25	0.10
1024	0.20	0.30	0.40	0.10*
512	0.45	0.50	0.50	0.00**
256	0.90	0.90	0.90	0.00***

Enzyme, 0.0125 per cent. Incubation period, 18 hours. 40° C.

This test was repeated the following day with only insignificant variations, the digestion period being only twelve hours.

It is very clear that zinc is more toxic than cadmium or cobalt. The amount of saponification allowed by zinc and cobalt at 2048 and at 1024 is, however, exactly the same, while cadmium at 2048 does not at all inhibit. On this basis zinc and cobalt are equal in toxicity, and both are more toxic than cadmium. In other cases it will be seen that relative toxicity based upon the concentration of total inhibition gives a different relation from that based upon the maximum concentration not inhibiting. This fact has been disregarded in concluding as to the relative toxicity and only the points of total inhibition compared.

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* Indicates the first appearance of a precipitate on titration, and the extra stars mean increasing quantity of precipitate.

Zinc, lead, and copper in contemporaneous test. —

TABLE V.

M.	Reagent.	Control.	Enzyme.	Increase.
		ZINC.		
1024	0.20	0.30	0.35	0.05
512	0.45	0.45	0.45	0.00
256	0.90	0.90	0.90	0.00
128	1.70	1.70	1.70	0.00
		LEAD.		
1024	0.10	0.20	0.25	0.05
512	0.20	0.30	0.30	0.00
256	0.45	0.60	0.60	0.00
128	0.90	1.10	1.10	0.00
		COPPER.		
1024	0.20	0.20	0.30	0.10
512	0.40	0.40	0.40	0.00
256	0.70	0.80	0.80	0.00
128	1.40	1.50	1.50	0.00

Enzyme, 0.0125 per cent. Incubation period, 5 hours. 40° C.

In this test the three salts are certainly of equal toxicity. The acidity of the control tends to be greater than that of the plain reagent, but this will be discussed later. It will be noted that the point of total inhibition for zinc is the same as in the preceding test, in which the incubation period was eighteen hours. This change in the incubation period does not materially change the relative toxicity even of different groups. A precipitate fell in each case at or near the neutral point.

Copper and zinc in contemporaneous test. — To show how closely the figures in successive tests will agree the results of two other tests with these salts will be given.

TABLE VI.

COPPER.

M.	Reagent.	Control.	Enzyme.	Increase.
2048	0.10	0.10	0.15	0.05
1024	0.20	0.20	0.20	0.00
512	0.40	0.40	0.40	0.00
256	0.70	0.80	0.80	0.00

TABLE VI (*continued*).

ZINC.

2048	0.10	0.15	0.25	0.10
1024	0.20	0.30	0.33	0.03
512	0.45	0.45	0.45	0.00
256	0.90	0.90	0.90	0.00

Enzyme, 0.0125 per cent. Incubation period, 4 hours. 40° C.

In this case 1024 of copper totally inhibits, while the corresponding concentration of zinc allows slight acidity. The difference is too small, however, to establish a positive difference in toxicity between the two salts.

Copper and lead in contemporaneous test. — A long time test is given here to show that the relative toxicity of these two salts is not modified, although the point of total inhibition is different.

TABLE VII.

M.	Reagent.	Control.	Enzyme.	Increase.
		COPPER.		
4096	0.05	0.07	0.20	0.13
2048	0.10	0.12	0.25	0.13
1024	0.20	0.20	0.30	0.10
512	0.40	0.40	0.45	0.05
256	0.70	0.75	0.78	0.03
128	1.40	1.50	1.50	0.00
		LEAD.		
4096	0.00	0.10	0.25	0.15
2048	0.05	0.20	0.35	0.15
1024	0.10	0.30	0.40	0.10
512	0.20	0.40	0.45	0.05
256	0.45	0.60	0.65	0.05
128	0.90	1.20	1.20	0.00

Enzyme, 0.0125 per cent. Incubation period, 17 hours. 40° C.

The difference in acidity between the control and the plain reagent tends to be greater in the case of the lead than of the copper. This is also noticeable in other tables, so that it would seem as though the action of lead on the enzyme is such as to generate acid products, more than in the case of copper.

Mercury, copper, and lead in contemporaneous test. —This test is to show that mercury exceeds copper and lead in toxicity.

TABLE VIII.

M.	Reagent.	Control.	Enzyme.	Increase.
		MERCURY.		
8192	0.00	0.05	0.08	0.03
4096	0.05	0.13	0.13	0.00
2048	0.10	0.15	0.15	0.00
1024	0.20	0.25	0.25	0.00
		COPPER.		
4096	0.05	0.08	0.30	0.22
2048	0.10	0.15	0.25	0.10
1024	0.20	0.20	0.25	0.05 *
512	0.40	0.40	0.40	0.00 **
		LEAD.		
4096	0.00	0.10	0.30	0.20
2048	0.05	0.10	0.30	0.20 *
1024	0.13	0.20	0.30	0.10 **
512	0.20	0.30	0.30	0.00 ***

Enzyme, 0.0125 per cent. Incubation period, 17 hours. 40° C.

In the case of mercury there was some sediment in each preparation, and apparently more in the control than in the unboiled. In the case of copper 2048 and 4096 preparations were free from sediment, but some was present in 512 and 1024, and apparently more in the boiled than in the unboiled solution. In the case of mercury a positive precipitation on titration could not be observed.

It will be noted that copper and lead yield practically the same figures as in preceding cases. Mercury is far more toxic than any of the others so far tried. In both mercury and lead the acidity of the control, as compared with that of the plain reagent, seems to be greater than in the case of copper.

Mercury and silver in contemporaneous test. — Since the acidity of the plain reagent in the case of both silver and mercury is zero for all the concentrations tried, this column is omitted from the tables.

The silver preparations were free from sediment, while every one of the mercury preparations contained a settled precipitate. It is to be noted that all the silver controls are neutral. Two of the mercury controls are acid in spite of the fact that the plain reagent is neutral.

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* Indicates the first appearance of precipitate on titration, and the extra stars mean increasing quantity of precipitate.

TABLE IX.

MERCURY.

M.	Control.	Enzyme.	Increase.
32768	0.00	0.00	0.00
16384	0.05	0.05	0.00
8192	0.07	0.07	0.00
		SILVER.	
32768	0.00	0.10	0.10
16384	0.00	0.05	0.05
8192	0.00	0.03	0.03

Enzyme, 0.0125 per cent. Incubation period, 4 hours. 40° C.

Since this test did not locate the limit for either salt, another was made the following day. In this latter test a repetition of the preceding (all conditions being the same), the mercury showed total inhibition in concentrations 8192–65536 inclusive. The figures for the silver are as follows:

TABLE X.

SILVER.

M.	Control.	Enzyme.	Increase.
32768	0.00	0.10	0.10
16384	0.00	0.05	0.05
8192	0.00	0.02	0.02
4096	0.00	0.00	0.00

This leaves the limit for mercury still undetermined while the figures for silver are almost identical with those found in the preceding test. The following experiment locates the limit for mercury and confirms antecedent figures for silver. All conditions are repeated as in the preceding test.

TABLE XI.

MERCURY.

M.	Control.	Enzyme.	Increase.
262144	0.00	0.05	0.05
131072	0.00	0.02	0.02
65536	0.00	0.00	0.00
32768	0.00	0.00	0.00
		SILVER.	
65536	0.00	0.10	0.10
32768	0.00	0.10	0.10
16384	0.00	0.05	0.05
8192	0.00	0.02	0.02
4096	0.00	0.00	0.00

Even when the fact that silver is univalent is allowed for, it is very evident that in these tests mercury is much more toxic than silver. Of course the chlorid of mercury is compared with the nitrate of silver, but this was also the case when Mathews found silver more toxic than mercury toward Fundulus eggs. Here is also the interesting observation that total inhibition may occur in neutral solutions at least neutral to the indicator under the conditions tried.

Zinc with ethylbutyrate absent. — That no question may arise as to the validity of my controls in the foregoing experiments, the following test is given here. The figures show that in the concentration used boiling does not change the acidity of the enzyme solution or introduce a disturbing factor. The filtered enzyme solution (0.025 per cent) was divided into two portions. One of them was boiled a moment over the free flame. There was no flocculation and the merest trace of opalescence. The initial acidity of the boiled and of the unboiled portions was zero. Preparations were made of the various concentrations of zinc nitrate, as indicated in the table, and after five hours' incubation the acidity again determined. The concentration of the enzyme was reduced one half in making the preparations as usual.

TABLE XII.

ZINC.

M.	Reagent.	Boiled.	Unboiled.
32768	0.00	0.00	0.00
16384	0.00	0.00	0.00
8192	0.00	0.00	0.00
4096	0.05	0.05	0 05
2048	0.10	0.10	0.10
1024	0.20	0.25	0.25
512	0.45	0.45	0.45
256	0.90	0.80	0.80
128	1.70	1.40	1.40
64	3.40	3.40	3.40

Enzyme, 0.0125 per cent. Incubation period, 4 hours. 40° C. Ethylbutyrate absent.

It is to be observed that the boiled and the unboiled solutions of the enzyme are identical in acidity in all the concentrations of the reagent. The control is therefore perfectly reliable, since, when the butyrate is added, any trace of acidity it carries is equally distributed. Also noticeable is the almost uniform agreement of the enzyme solutions with the plain reagent, indicating that the concentration of the enzyme product is too slight to displace the point of neutralization. A comparison of the figures for the boiled solution in this test with those for the control in preceding zinc tests shows that the latter tend to run a little higher. This must be due to slight acidity of the ethylbutyrate rather than to any enzyme action of the boiled extract.

By way of recapitulation it may be said that the tests show a very marked grouping of the metals according to toxicity, and that the limits are sharp and do not overlap even when the extreme allowance for error is made. Thus it does not seem quite certain that lead and zinc are of equal toxicity; however, copper can hardly be classed by itself and certainly not as approaching equality with silver. On the equinormal basis mercury is certainly eight times more toxic than silver and probably sixteen times. Silver is sixteen times as toxic as copper, lead, or zinc. Cadmium and cobalt are only one fourth as toxic as copper, lead, or zinc, and only twice as toxic as barium, strontium, magnesium, or ammonium. This arrangement of the metals according to toxicity disagrees with that of Mathews, McGuigan, and Caldwell in several particulars, most notably in the relative toxicity of mercury and silver. All three of those men found silver to be more toxic than mercury.

If the degree of toxicity of a series of metals varies inversely with the solution tension of those metals, the relative toxicity of any pair would be theoretically and approximately, at least, the reciprocal of the relative solution tension. Thus, copper, having about one fifth the solution tension of lead, should be five times more toxic. In the following table, in the column headed "Theory," are given a few of the ratios derived from the table of solution tension as quoted by Mathews. In the column headed "Found" are given the ratios resulting from my own experiments. The figures are based upon equinormal concentration, since Mathews's table of the values for the respective solution tensions of the metals is for those metals in equinormal solutions.

	Theory.	Found.
Mercury and silver	1 : 1	8 : 1
Copper and lead	5 : 1	1 : 1
Lead and cobalt	3 : 1	4 : 1
Cadmium and zinc	3 : 1	1 : 4
Zinc and cadmium	5 : 1	64 : 1

The solution tension of mercury and silver is about equal, and hence according to Mathews's theory they should be about equal in toxicity. When the other ratios are also considered, it is evident that the disagreement between theory and experiment is greater than the agreement, and one would be reluctant to formulate a law upon such slight conformity.

In this connection it is interesting to note the general agreement given by Mathews[1] in a comparison of the actual toxicity, as found by him, and the theoretical, as computed according to his own formula for the use of solution tension as a basis of computation. Mathews's Table VI. gives the computed and found values of the minimum fatal dose in terms of a normal solution. Thus, the computed value for KCL is given as 0.948, and the found as 0.507. This is a considerable difference, and expressed upon the percentage basis means that the computed is greater than the found by 87 per cent. The following summary gives the difference between the computed and found, as calculated from Mathews's table:

Calcium chlorid	Computed is greater than found by	50	per cent.
Barium chlorid	“ “ “ “ “ “	55	“ “
Potassium chlorid	“ “ “ “ “ “	87	“ “
Zinc chlorid	“ “ “ “ “ “	266	“ “
Aluminum chlorid	Computed is less than found by	86	“ “
Magnesium chlorid	“ “ “ “ “ “	102	“ “
Manganese chlorid	“ “ “ “ “ “	133	“ “
Ferrous chlorid	“ “ “ “ “ “	531	“ “

The following agree sufficiently well: Cobalt, ferric iron, nickel, copper, mercury, sodium, and lithium. Of the fifteen here considered, four deviate more than 100 per cent, and four as much or more than 50 per cent.

Here, again, it is merely a matter of judgment as to the conclusion to be drawn. Of course, the difference between theory and experiment expressed in per cent is often large, even in ordinary reactions with inanimate matter; but I think it would be perfectly safe to say that such figures leave solution tension, as a determining factor in toxicity, in considerable doubt.

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[1] MATHEWS: *Loc. cit.*

RELATIVE TOXICITY WITH THE CONCENTRATIONS OF ENZYME DIFFERENT.

One of the conclusions reached by Caldwell is that the metals maintain their *relative* toxicity regardless of the concentration of the enzyme or of protein impurities. A relatively small increase of protein impurity was found by him to very much increase the concentration of the toxic agent necessary for inhibition. The relative toxicity of the metals remained the same, although the concentrations of inhibition were different. My own experience does not agree with this, as the following tests show. In the preceding tests I found cobalt and cadmium to be equal, while zinc was four times more toxic under the conditions tried than either. From the following tables it will be seen that when the concentration of the enzyme is increased the three metals are about equal in toxicity.

Zinc. — In this and in subsequent tests the controls were not boiled, because in the higher concentrations of the enzyme solution there is a flocculation on boiling, and in pipetting from such a boiled solution the coagulum cannot be as evenly distributed to the members of a given series as in the method used. This was simply to pipette the unboiled enzyme solution to each vial containing the toxic salt solution, and then to place the vials in cold water and bring the water to boiling. The controls, therefore, were not actually boiled, but the heat and the toxic salt combined were certainly adequate to destroy all activity of the enzyme. The tables show that this treatment insured a reliable control. The concentration of the enzyme, as recorded in the table, was 0.125 per cent. It was, however, actually less. The paste formed by the trituration of 0.5 gm. in a few drops of water was diluted to 200 c.c. and filtered. Of that filtrate 2 c.c. were used in each vial, thus reducing the concentration of the enzyme by one half. Since so much residue remained upon the filter, the actual concentration of the enzyme must have been less than the percentage figures given. The coagulum on heating shows that the concentration was at least greater than that used in the earlier tests, where coagulation did not occur:

TABLE XIII.

ZINC.

M.	Reagent.	Control.	Enzyme.	Increase.
16384	0.00	0.15	1.10	0.95
8192	0.00	0.15	1.05	0.90

TABLE XIII (*continued*).

4096	0.05	0.15	1.00	0.85
2048	0.10	0.20	1.00	0.80
1024	0.20	0.30	1.00	0.70
512	0.45	0.50	1.00	0.50
256	0.90	0.90	1.40	0.50
128	1.70	1.80	2.10	0.30
64	3.40	3.40	3.60	0.20
32	6.70	6.70	6.70	0.00
Water	....	0.15	1.10	0.95

Enzyme, 0.125 per cent. Incubation period, 4 hours. 40° C.

This shows that 32 is the toxic limit under the conditions of the test. There is only slight inhibition at 8192, and none at 16384. Notable is the fact that, while the enzyme has an initial acidity of 0.15, and the control also has this value of acidity in the concentrations of the reagent having no acidity, as the acidity of the reagent increases by concentration, the acidity of the control and reagent become more nearly equal, and finally are the same. This is interesting in connection with the results of tests soon to be given here, which show that the toxicity of the metals tends toward equality with increasing concentration of the enzyme. The following table shows that there is a reaction between the toxic agent and the substance of the enzyme solution. In this test the ethylbutyrate was omitted.

TABLE XIV.

ZINC.

M.	Reagent.	Boiled.	Unboiled.
32768	0.00	0.15	0.25
16384	0.00	0.15	0.25
8192	0.00	0.15	0.25
4096	0.05	0.15	0.25
2048	0.10	0.20	0.28
1024	0.20	0.25	0.36
512	0.45	0.50	0.50
256	0.90	0.85	0.85
128	1.70	1.70	1.70
64	3.40	3.40	3.40
Water	....	0.15	0.30

Enzyme, 0.25 per cent. Incubation period, 4 hours. 40° C. Initial acidity of the boiled and unboiled enzyme solution with toxic agent absent and before incubation = 0.15.

Before titration, at the close of the incubation period, it was noted that in the unboiled preparations having the toxic agent present in concentration of above 1024 there was no sediment or precipitate in suspension. In 1024 there was no sediment, but there was some precipitate in suspension. With increasing concentration of the agent the quantity both of sediment and of precipitate in suspension increased perceptibly to the eye. The sediment seems to be identical with the precipitate in suspension. The final acidity of the unboiled is just double the initial acidity. The final and initial acidity of the boiled enzyme solutions is, however, identical. Boiling, therefore, stops autolysis. The enzyme solution used was the filtrate from 1 gm. of powder mixed with 200 c.c. of water. On heating this filtrate over the free flame there was slight turbidity at about 45° C., flocculation at about 70°. Boiling was continued for only a moment.

Several points of interest are to be noted here. The acidity of 4 c.c. of the reagent in concentrations 8192–32768 inclusive is 0. The acidity of the boiled enzyme containing the toxic agent in those same concentrations is 0.15, or just exactly what it is if the toxic agent is not present. In the unboiled preparations corresponding to these concentrations, the autolysis, though very slightly checked, is almost the same as though the agent were not present. Comparison with other tables shows that the very same relations are sustained here as in those cases where the ethylbutyrate is present during the incubation.

Cobalt. —

TABLE XV.

COBALT.

M.	Reagent.	Control.	Enzyme.	Increase.
8192	0.00	0.15	1.10	0.95
4096	0.00	0.15	1.10	0.95
2048	0.00	0.15	1.10	0.95
1024	0.00	0.20	1.10	0.90
512	0.00	0.30	1.10	0.80
256	0.02	0.50	1.30	0.80
128	0.05	1.40	1.80	0.40
64	0.10	2.60	2.90	0.30
32	0.20	3.20	3.20	0.00
Water	....	0.15	1.10	0.95

Enzyme, 0.125 per cent. Incubation period, 4 hours. 40° C.

The point of total inhibition is 32, just the same as for zinc. In the concentrations greater than 512 the end reaction on titration is not sharp. The reagent itself, however, has a very sharp end reaction. In the higher dilutions of the plain reagent there is no precipitation, even at the neutral point. In greater concentrations of the plain reagent there is a precipitate at the neutral point. If the enzyme is present the precipitate appears long before the neutral point is reached, and as the alkali is added the precipitate takes up the purple for some time before the liquid shows alkalin. This accounts for the fact that the acidity of the control is so greatly in excess of the sum of the acidity of the enzyme and of the plain reagent. Compare with mercury in this particular:

Cadmium. —

TABLE XVI.

CADMIUM.

M.	Reagent.	Control.	Enzyme.	Increase.
8192	0.00	0.10	1.10	1.00
4096	0.00	0.10	1.00	0.90
2048	0.00	0.15	0.95	0.80
1024	0.00	0.20	1.00	0.80
512	0.00	0.25	0.95	0.70
256	0.00	0.40	0.85	0.45
128	0.05	0.70	1.20	0.50
64	0.10	1.20	1.25	0.05
32	0 20	1.60	1.60	0.00
Water	....	0.10	1.10	1.00

Enzyme, 0.125 per cent. Incubation period, 4 hours. 40° C.

The same remarks concerning the end reaction are applicable here as in the case of cobalt, although I could not see that the precipitate turned purple before the liquid, as was the case with cobalt. The point of total inhibition is at 32, which is identical with cobalt and zinc. Since these tests were not contemporaneous, and, therefore, not strictly comparable, the following test is given:

Cadmium, cobalt, and zinc in contemporaneous test. —

TABLE XVII.

M.	Control.	Enzyme.	Increase.
		CADMIUM.	
32	1.40	1.40	0.00
64	1.00	1.30	0.30
		COBALT.	
32	3.20	3.20	0.00
64	2.50	2.80	0.30

TABLE XVII (*continued*).

Zinc.

32	6.70	6.70	0.00
64	3.30	3.60	0.30

Enzyme, 0.125 per cent. Incubation period, 5 hours. 40° C.

This shows the approximately equal toxicity of these metals under these conditions. If the concentration of the enzyme is reduced, but not so much as in Table IV, it is seen that the greater toxicity of zinc reappears.

Cadmium and zinc in contemporaneous test. —

TABLE XVIII.

Cadmium.

M.	Control.	Enzyme.	Increase.
128	0.20	0.50	0.30
64	0.50	0.50	0.00
		Zinc.	
128	1.80	1.80	0.00
64	3.30	3.30	0.00

Enzyme, 0.02 per cent. Incubation period, 17 hours. 40° C.

Here, in spite of the long incubation period, the greater toxicity of zinc is apparent.

Mercury, copper, and lead show the same tendency to be of equal toxicity with increasing concentration of the enzyme.

TABLE XIX.

Mercury (Chlorid).

M.	Reagent.	Control.	Enzyme.	Increase.
32768	0.00	0.15	1.10	0.95
16384	0.00	0.15	0.90	0.75
8192	0.00	0.15	0.80	0.65
4096	0.05	0.15	0.60	0.45
2048	0.10	0.15	0.50	0.35
1024	0.20	0.20	0.60	0.40
512	0.35	0.30	0.60	0.30
256	0.65	0.70	0.80	0.10
128	1.30 *	1.10	1.10	0.00
64	2.50 *	2.20	2.20	0.00
Water	....	0.15	1.10	0.95

Enzyme, 0.25 per cent. Incubation period, 4 hours. 40° C.

* A red precipitate.

The point of total inhibition for this concentration is thus seen to be 128. Under conditions similar to these lead and copper will show exactly the same point. Notable here is the fact that the acidity of the control is less than that of the plain reagent at the concentration of the plain reagent at which a red precipitate appears upon titration. In the control and in the enzyme solution a red precipitate does not appear on titration either at 128 or at 64. The protein of the enzyme solution prevents the formation of the precipitate, and some of the natural acidity of the reagent is probably united to it.

TABLE XX.

COPPER.

M.	Reagent.	Control.	Enzyme.	Increase.
65536	0.00	0.20	1.60	1.40
32768	0.00	0.20	1.60	1.40
16384	0.00	0.20	1.60	1.40
8192	0.00	0.20	1.60	1.40
4096	0.05	0.20	1.50	1.30
2048	0.10	0.20	1.50	1.30
1024	0.20	0.25	1.00	0.75
512	0.40	0 30	0.90	0.60
256	0.70	0.50	0.90	0.40
128	1.40	1.40	1.40	0.00
64	2.80	2.60	2.60	0.00
Water	....	0.20	1.60	1.40

Enzyme, 0.25 per cent. Incubation period, 4 hours. 40° C.

Notable is the fact that dilutions above 4096 are indifferent, but there is no trace of stimulation. As in the case of mercury, the acidity of the control is less than that of the plain reagent near the point of total inhibition.

TABLE XXI.

LEAD.

M.	Reagent.	Control.	Enzyme.	Increase.
16384	0.00	0.15	1.40	1.25
8192	0.00	0.15	1.30	1.15
4096	0.00	0.15	1.10	0.95
2048	0.05	0.20	1.10	0.90
1024	0.10	0.20	1.00	0.80
512	0.20	0.30	1.00	0.70
256	0.45	0.50	0.90	0.40
128	0.90	1.00	1.00	0.00
64	1.80	1.80	1.80	0.00

Enzyme, 0.25 per cent. Incubation period, 4 hours. 40° C.

The same point of total inhibition is found here as in the case of mercury and copper. The relative acidity of the reagent and control is different, however. The difference in acidity between the control and the reagent steadily increases to zero at the point of total inhibition. There is something of individuality in the behavior of the toxic salts to the protein of the enzyme solution. Since the tests for mercury, lead, and copper were conducted separately, the following contemporaneous test for mercury and lead is given.

Mercury and lead in contemporaneous test. —

TABLE XXII.

M.	Control.	Enzyme.	Increase.
		MERCURY.	
256	0.80	0.90	0.10
128	1.50	1.50	0.00
64	2.60	2.60	0.00
		LEAD.	
256	0.60	0.90	0.30
128	1.20	1.20	0.00
64	2.00	2.00	0.00

Enzyme, 0.25 per cent. Incubation period, 4 hours. 40° C.

Just why the acidity of the controls in this test is so much higher than in the preceding separate tests is not known. However, both the mercury and copper controls are higher, so that perhaps the ethylbutyrate was not quite neutral. Even so, the same relative toxicity is maintained in a contemporaneous test.

DISCUSSION.

The solutions of sodium, lithium, potassium, ammonium, barium, strontium, and magnesium, are all neutral, and so are the corresponding controls for the concentrations of the enzyme tried. In those cases there is no evidence of chemical reaction between the substance of the enzyme solution and the reagent. With the other reagents tried (Cu, Pb, Cd, Co, Zn, Hg, and Ag) there is evidence of such chemical action, and it seems but natural to suppose that the cause of toxicity is very different in the one group from that in the other. The latter solutions show natural acidity, and this is more or less affected by the substance of the enzyme solution, even though the latter be too dilute to coagulate upon boiling, or have any initial acidity.

In the case of zinc the reagent and the control acidity are equal at the point of total inhibition. This same relation of control and reagent acidity is again seen with greater concentration of the enzyme for cadmium in Table XVI, cobalt in Table XV, and zinc in Table XVII. This indicates a difference in the action between zinc and the other two, and a similarity between cobalt and cadmium. Referring to Tables XIII, XX, and XXI, we see that copper, lead, and zinc are alike, in that the acidity of control is less than the sum of reagent acidity and the initial acidity of the enzyme solution, but that the control acidity is greater than that of the reagent, and that the difference decreases to zero at the point of total inhibition. That this relation holds in the case of zinc, at least in the absence of butyrate, is seen in Table XIII. In Table XIX mercury seems to be different in behavior from any of the others. At the point of total inhibition the acidity of the control is less than that of the reagent. Mercury is the only one which precipitates the enzyme during incubation in the 0.0125 per cent concentration of the enzyme. These relations acquire significance when we find that the similarities are correlated with relative toxicity, at least in the case of the highest dilution of the enzyme tried. Thus copper, lead, and zinc are equal, which is also true of cobalt and cadmium. The more acidity consumed in the union of the reagent and the enzyme substance, the greater the toxicity.

It is the intention to further investigate some of the correlations apparent in this study, but so far as ionic potential as a determining factor in toxicity is concerned, my results, in accord with those of Berg and Gies,[1] not only fail to furnish support to such a law, but show that in the lipolysis tested toxicity does not vary inversely with the solution tension. On the other hand, a reaction, in the case of electrolytes at least, in which solution tension is not a factor, is hardly imaginable, but the same is true of temperature, etc.

CONCLUSION.

The toxicity of the salts tested does not under the conditions herein specified, vary inversely with the decomposition tension of those salts.

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[1] BERG, W. N., and GIES, W. J.: Journal of biological chemistry 1907, ii. pp. 489–546.

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STUDIES IN NORTH AMERICAN PERONOSPORALES—II

PHYTOPHTHOREAE AND RHYSOTHECEAE

By GUY WEST WILSON

NEW YORK
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Studies in North American Peronosporales—II. Phytophthoreae and Rhysotheceae

GUY WEST WILSON

The family *Peronosporaceae*, which includes all the genera of the order except *Albugo*, may be briefly characterized as follows:

Mycelium intercellular; conidiophores aerial, variously branched; conidia borne singly at the apex of the ultimate branchlets of the coniophores, germinating by zoöspores or rarely by a germ-tube; oöspores globular, variously sculptured, germinating by a germ-tube.

Of the three well-defined tribes which constitute this family, the first two are discussed in this paper. It is usual to follow the older authors in considering the species embraced in the genera at present under discussion, as clearly distinguished from the remaining members of the family by the method of germination of the conidia, which in the *Phytophthoreae* and *Rhysotheceae* is normally by zoöspores, while those of the *Peronosporeae* germinate by means of a germ-tube. It is, however, well known that under certain conditions the conidia of these species do not throw out zoöspores, but produce one or more germ-tubes. This is probably due to conditions which cause the potential zoöspores, which are already formed within the conidium, to germinate before escaping from the conidial membrane.* With this real or apparent intergradation of characters, it is desirable to have a more stable basis for grouping the genera within the family. Characters which are much more easily observed and subject to less important variation are afforded by the conidiophores, the habit of branching of which conforms to the method of conidial germination.

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* See Hartig, Unters. Forstbot. Inst. München 1: *pl. 3*.

Like many other plants, the *Peronosporaceae* do not lend themselves readily to characterization. The conidia vary greatly in size and often to a surprising extent in outline, and the conidiophores from their very nature are difficult of description. For this reason it appears desirable to add the heading "icones" under which as complete a list as practicable of illustrations in American works and the chief foreign ones is given for each species. A key to the genera is also given in which the three tribes are characterized and the genera under the first two included, the third tribe being reserved for future treatment.

A serious handicap in the treatment of the species of this family is the lack of information upon many points which are of taxonomic importance. While in America the present family has received more attention than almost any other group of *Phycomycetes*, a wide field for investigation is still open. The oöspores of many species are unknown, and even when known are of rare occurrence in herbaria; the germination of but few species has been studied in America, our knowledge on this point being frequently derived from European sources; the problems of oögenesis are practically untouched; but few inoculation experiments have been conducted to determine the range of hosts which a single species will affect. It is therefore apparent that a final, or even a reasonably satisfactory treatment of the group at the present time is impracticable.

In conclusion I wish to express my sincere appreciation of the courtesies shown me in my work, and especially to those botanists who have so kindly supplied me with material in addition to that which was available in preparing the previous paper of this series.

Conidiophores not clearly differentiated from the mycelium, scorpioid-cymosely branched; conidia germinating normally by zoöspores. PHYTOPHTHOREAE.
  A single genus. 1. *Phytophthora.*
Conidiophores clearly differentiated from the mycelium.
  Conidiophores monopodially branched, the branches usually arising at right angles to the main axis, successively shorter; conidia germinating normally by zoöspores. RHYSOTHECEAE.
    Conidiophores with the main axis indurate above, the lateral branches reduced and basidium-like. 2. *Basidiophora.*
    Conidiophores with the main axis not indurate above, the lateral branches developed normally.
      Conidiophores fugaceous, stout, sparingly branched; oöspores permanently united to the walls of the oögone. 3. *Sclerospora.*

- Conidiophores persistent, slender, usually freely branching; oōspores free from the walls of the oōgone.
  - Branches of the condiophore apically obtuse. 4. *Rhysotheca.*
  - Branches of the conidiophore apically acute. 5. *Pseudoperonospora.*
- Condiophores dichotomously branched, the branches arising at right angles to the main axis, successively shorter; conidia germinating by a germ-tube. PERONOSPOREAE.

1. PHYTOPHTHORA de Bary, Jour. Roy. Agr. Soc. England II. **12**: 240. 1876.

Mycelium much-branched, hyaline; conidiophores arising singly or in groups from the stomata, or breaking through the epidermis, branched or apparently simple, with irregular thickenings below the conidia, which are borne apically in a scorpoid cyme; conidia oval, papillate; zoōspores oval, biciliate, escaping by the rupture of the papilla; oōspores intramycelial, the epispore more or less ridged.

Type species, *Peronospora infestans* Casp.

Herbarium material of the species of this genus is very unsatisfactory for study, as the conidiophores form a very dense covering to the host, and being quite flaccid and often very long they form at maturity a dense felt in which the individual conidiophores are effectively obscured. This is especially true of *P. infestans*, while some of the foreign species are not difficult to study.

Key to the species

- Conidia usually only one, rarely two, borne at the apex of an aborted cyme; conidiophore simple or branched below.
  - Host Fabaceae. 1. *P. Phaseoli.*
  - Host Araceae. 2. *P. Colocasiae.*
- Conidia numerous in a simple or compound cyme.
  - Conidia sessile or long-stalked in a simple cyme.
    - Conidia small, about 35 μ. 3. *P. Nicotianae.*
    - Conidia large, 50μ, or more. 4. *P. Cactorum.*
  - Conidia sessile in a compound cyme.
    - Host Solanaceae. 5. *P. infestans.*
    - Host Ranunculaceae. 6. *P. Thalictri.*

1. PHYTOPHTHORA PHASEOLI Thaxter, Bot. Gaz. **14**: 274. 1889

The present species differs rather markedly from the other American species of the genus in the method of branching of the conidiophores, but in other respects they are quite similar. The conidiophores are very long, simple, or more commonly branched at the base, and bear a single apical conidium, below which are several swellings of the conidiophore which indicate the typical cymosely branched conidiophore upon which the majority of conidia have failed to develop. This species, first described by Dr. Thaxter, has attracted the attention of various mycologists, among them Dr. Clinton, who has recently published a very complete discussion of this destructive parasite of the lima bean.* His article is accompanied by illustrations of the oōspores and a complete bibliography of the species.

ON FABACEAE:

Phaseolus lunatus L., Connecticut, *Clinton* (Fungi Columb. *1949*), *Rorer* (Funghi Par. Piant. Colt. *351*), *Thaxter* (Econ. Fungi *9*, N. Am. Fungi *2707*); Delaware, *Jackson 1554*.

TYPE LOCALITY: New Haven, Connecticut, on *Phaseolus lunatus* L.

DISTRIBUTION: Connecticut to Maryland. Also in European Russia.

ICONES: Rep. Conn. Agr. Exp. Sta. **1900**: *pl. 3. f. 29–37;* **1905**: *pl. 20–22;* Bull. N. J. Agr. Exp. Sta. **151**: 19. *f. 6.*

2. PHYTOPHTHORA COLOCASIAE Racib. Parasit. Algen u. Pilze Javas **1**: 9. 1900

This species, which is very closely related to *P. Phaseoli*, is said, by its author, to be very abundant on the taro, *Colocasia antiquorum*, throughout Java, but apparently not damaging the host. The fungus is to be expected in other tropical countries in which the host is cultivated.

3. PHYTOPHTHORA NICOTIANAE Van Breda de Haan, Meded. Lands Plant. **15**: 41. 1896

The present species, which is illustrated and described in great detail by its author, is a serious tobacco pest in the East Indies and may appear elsewhere at any time.

4. PHYTOPHTHORA CACTORUM (Lebert & Cohn) Schröter, in Cohn, Krypt. Fl. Schles. 3^1: 274. 1886

Peronospora Cactorum Lebert & Cohn, Beitr. Biol. Pflanz. 1^1: 56. 1870.

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*Ann. Rep. Conn. Agr. Exp. Sta. **1905**: 278–303. *pl. 20–22.* 1906.

Phytophthora omnivora de Bary, Bot. Zeit. **39**: 584, 619. *pl. 5. f. 33–41.* 1881.

This species has long been a scourge in Europe on account of its attacks upon seedlings and succulents, its hosts including representatives of fifteen families ranging from *Pinaceae* to *Scrophulariaceae*. Until quite recently this species was not reported from other countries, its first record from foreign quarters being in connection with a serious outbreak of a pod-rot of cacao in the island of Trinidad.* Material was sent to Massee, who identified one of the fungi concerned as *Phytophthora omnivora* de Bary. His description † is of a popular nature and would apply equally well to any one of several groups of fungi, while his figures are unmistakably of a species of *Phytophthora* of the same type as the present one. The conidia are somewhat more elongate and attenuate than usual. This, taken with the habitat, suggests that the pod-rot of the cacao may be caused by a distinct but closely related species, but no definite statement can be made without first examining fresh material. Since the first report of the outbreak of the disease, it has been reported from various other localities in the West Indies, South America, Asia and Africa. The history, distribution and nature of the disease are fully discussed by Howard.‡ The species is also included by Freeman in his Minnesota Plant Diseases § as a pest in seed-beds.

5. PHYTOPHTHORA INFESTANS (Mont.) de Bary, Jour. Roy. Agr. Soc. England II. **12**: 240. 1876

Botrytis infestans Mont. Mém. Inst. France **1845**: 313. 1845.

Peronospora infestans Casp. in Rabenh. Herb. Viv. Myc. I. *1879.* 1854.

As one of our worst plant diseases is caused by the present species its distribution is rather well worked out. While the fungus is not so prevalent, except in localities where the potato is cultivated in large commercial quantities, the range of both appears to be coextensive. It is, however, much more destructive in the northern than in the southern states, as it requires a cool, moist atmosphere in which to develop to the best advantage. Besides the potato, which is its chief host, the fungus attacks numerous other species of the genus *Solanum* as well as members of various other genera of *Solanaceae*.

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* Hart, Bull. Trinidad Bot. Gard. **3**: 167–169. Ja 1899.

† Kew Bull. Misc. Inf. **1899**: 1–6. *plate.* 1899.

‡ West Indian Bull. **2**: 190–211. 1901.

§ Page 382. 1905.

ON SOLANACEAE:

Solanum tuberosum L., Connecticut, *Clinton* (Fungi Columb. *1839*); Illinois, *Burrill, Seymour* (N. Am. Fungi *2204*); Iowa, *Blackwood, Buchanan, Holway, Pammel;* New York, *Ellis* (Fungi Carol. 5: *92*), *Whetzel;* Tennessee, *Scribner* (Econ. Fungi *447*); Vermont, *Jones;* Wisconsin, *Pammel, Trelease.*

Lycopersicon Lycopersicon (L.) Karst., Delaware, *Smith* (Fungi Columb. *2138*); South Carolina, *Ravenel* (Myc. Univ. *926*).

TYPE LOCALITY: France, on *Solanum tuberosum* L.

DISTRIBUTION: Eastern Canada to California and Florida. Also in South America, Europe, Asia, Africa, and Australia.

ICONES: Bot. Zeit. **5**: *pl. 6. f. 1–6;* Bull. Bussey Inst. **1**: 319. *fig.*; Bull. Ill. Lab. Nat. Hist. **1**^{1}: *pl. 2. f. 8–10;* Frank, Lehrb. Bot. **2**: 114. *f. 321;* Rep. U. S. Dep. Agr. **1888**: *Veg. Path. pl. 1, 2;* Rep. Maine Agr. Exp. Sta. **1889**: 172. *f. 1–10;* Rep. Vt. Agr. Exp. Sta. **1890**: 132. *fig.;* Rep. N. J. Board Agr. **17**: *pl. 4;* v. Tubeuf, Pflanzenkrankheiten 142. *f. 31;* Bull. Calif. Agr. Exp. Sta. **175**: *f. 3, 6–8;* Berlese, Icon. Fung. Phyc. *pl. 8.*

6. **Phytophthora Thalictri** Wilson & Davis

Hypophyllous, the infested area suborbicular or irregular in outline, appearing somewhat glaucous; epiphyllous discoloration very dark, almost black, sometimes with a distinct brownish margin; conidiophores fasciculate from the stomata, continuous, lax and somewhat flexuose, rather scattered on the infested area and not forming a dense felt, 300–400 × 5–7 μ, bearing usually 1 or 2 branches, subconidial swellings narrowly conical, less than twice as thick as the branch; conidia elliptic, apically papillate, 20–27 × 13–17 μ; oöspores unknown.

Type collected by Dr. J. J. Davis, June 20, 1907, in Kenosha County, Wisconsin, on *Thalictrum purpurascens* L.

Distinguished from *P. infestans* by the more pronounced discoloration of the infested area and the less disastrous effect on the host; the shorter and more slender conidiophores which form a sparse covering to the infested area instead of forming a dense felt as in the other American species, and which are more persistent than is common in the genus; the slightly smaller and more elongate conidia. The material collected by Dr. Davis was all on a single plant of the host which is rather common in that region. Specimens of the type collection are in the herbaria of Dr. Davis, of the New York Botanical Garden, and of the author.

2. BASIDIOPHORA Roze & Cornu, Ann. Sci. Nat. V. **11**: 84. 1869

Mycelium much-branched; conidiophores clavate, the apex an enlarged indurate axis upon which short, simple, cylindric lateral branches are borne alternately; conidia ovate to globose-ovate, smooth, hyaline, apically papillate, breaking away with a portion of the branch attached; zoöspores biciliate, monoplanal; oöspores produced in the tissues of the host in company with the conidiophores; epispore yellowish-brown, more or less irregularly ridged.

Type species, *Basidiophora entospora* Roze & Cornu.

The species of this genus are easily recognized by the clavate conidiophore with its short cylindric fertile branches. The only approach to this type of branching among the other members of the tribe is in the monotypic Japanese genus *Kawakamia* Miyabe, which is described as having the conidiophores "simple or sometimes branched without any order, generally only once and that not from the base of the conidium, slender and provided generally at the tip with a short pedicel-cell, which is more slender than the conidiophore," which is "swollen at base, and gradually tapering toward the tip."*

Key to the species

Conidiophores tall, reaching 300μ; conidia ovate; oöspores with prominent ridges.	1. *B. entospora.*
Conidiophores short, not over 100μ; conidia globose-ovate; oöspores with very obscure ridges.	2. *B. Kellermanii.*

1. BASIDIOPHORA ENTOSPORA Roze & Cornu, Ann. Sci. Nat. V. **11**: 84. 1869

Peronospora entospora Berk. & Br. Grevillea **1**: 20. 1872.

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* Bot. Mag. Tokyo **17**: (306). 1903.

Peronospora simplex Peck, Ann. Rep. N. Y. State Mus. Nat. Hist. **31**: 45. 1879.

Plasmopara entospora Schröt. in Cohn, Krypt. Fl. Schles. 3^1: 237. 1886.

Hypophyllous, forming angular areas 1–8 mm. across, bounded by the veins of the leaf; conidiophores arising from the stomata, singly or in groups, hyaline, 150–300 × 8–20 μ, apically much enlarged, 17–25 μ, lateral branches 5–20, about 6–10 × 2 μ; conidia ovate, 20–36 × 10–20 μ; oöspore light yellowish-brown, 40–50 μ; epispore conspicuously ridged.

ON CARDUACEAE:

Aster Novae-Angliae L., Indiana, *Wilson;* Wisconsin, *Trelease* (N. Am. Fungi *1405*).

Aster oblongifolius Nutt., Nebraska, **Bates* (Fungi Columb. *1950*).

Erigeron philadelphicus L., Louisiana, *Langlois 1669.*

Erigeron ramosus (Walt.) B. S. P., Illinois, *Earle, Waite.*

Leptilon canadense (L.) Britton, Missouri, **Pammel.*

Solidago rigida L., Illinois. * *Seymour* (N. Am. Fungi *1405b*, Fungi Europ. *3277*).

Reported also from our limits on *Aster sagittifolius* Willd. and *Rudbeckia fulgida* Ait.

TYPE LOCALITY: France, on *Leptilon canadense* (L.) Britton.

DISTRIBUTION: New York to Wisconsin, Nebraska, Texas, and Alabama. Also in Europe and South America.

ICONES: Ann. Sci. Nat. V. **11**: *pl. 4;* Rabenh. Krypt. Fl. ed. 2. 1^4: 424. *f. 68;* Berlese, Icon. Fung. Phyc. *pl. 7.*

2. **Basidiophora Kellermanii** (Ellis & Halsted).

Peronospora Kellermanii Ellis & Halsted "*pro tem.*"; Ellis & Everh. N. Am. Fungi *2201.* 1889. (Hyponym.)

Plasmopara sp. Swingle, Trans. Kan. Acad. Sci. **11**: 74. 1889.

Plasmopara Kellermanii Swingle; Sacc. Syll. Fung. **9**: 342. 1891.

Hypophyllous, forming angular discolored patches which often cover a large portion of the leaf; conidiophores arising from the stomata, singly or in groups, very short, hyaline, 25–100 × 8–10 μ, apically much enlarged, about 15–20 μ; lateral branches 4–7, short, 5–8 × 2 μ; conidia globose-ovate, 20–22 × 18–20 μ; oöspores yellowish-brown, obscurely ridged, 30–40 μ.

This species has an interesting history, and, while known for some years, it has never been fully described. That it is abundant in those localities where it occurs is evidenced not only by the quotation below, but by the additional fact that in three instances material has been collected in sufficient quantity for distribution in exsiccati. The original collection was distributed in North American Fungi *2201*, where it received its first name. A description was drawn at the same time by Dr. Halsted, to whom the material was submitted for determination, but this is still unpublished. Swingle's note on the species forms the basis of the diagnosis in Saccardo's *Sylloge Fungorum* and is as follows:

"This species has not yet been published, but seems to be a *Plasmopara* allied to *P. entospora*, from which it differs in having shorter fasciculate conidiophores and almost sessile conidia, which are smaller than in some forms of *P. entospora.* It is a very abundant and curious species, as yet little understood."

In addition to these points of difference attention should be called to the more globular conidia, the darker oöspores with their less conspiciously ridged epispore, and the larger infested area with more pronounced discoloration of the host in the present species than in the former.

ON AMBROSIACEAE:

Iva xanthiifolia Nutt., Kansas, **Bartholomew* (Fungi Columb. *1841*), **Kellerman* (N. Am. Fungi *2201*); Nebraska, **Pammel*, **Sheldon;* North Dakota, **Seaver;* South Dakota, **Griffiths* (W. Am. Fungi *191*); Wyoming, **Pammel & Stanton.*

TYPE LOCALITY: Manhattan, Kan., on *Iva xanthiifolia* Nutt.

DISTRIBUTION: North Dakota and Wyoming to Kansas.

ICON: Freeman, Minn. Pl. Diseases 111. *f. 45.*

3. SCLEROSPORA Schröter; de Bary, Bot. Zeit. 39: 621. 1881

Peronospora § *Sclerospora* Schröter, Hedwigia **18**: 86. 1879.

Mycelium much branched, with small vesicular haustoria; conidiophores erect, solitary or in groups of 2–3, fugaceous, low and stocky, sparsely branched, the branches also stocky; conidia elliptic or globose-elliptic, hyaline, smooth; oöspores intramycelial, the epispore brown, irregularly wrinkled, permanently united to the persistent wall of the oögonium.

Type species, *Protomyces graminicola* Sacc.

Key to the species

Oöspore small, 26–36 μ; epispore not pronouncedly opaque; host, *Chaetochloa*.	1. *S. graminicola*.
Oöspore large, 28–45 μ; epispore very opaque; host, *Chloris*.	2. *S. Farlowii*.

1. SCLEROSPORA GRAMINICOLA (Sacc.) Schröter, in Cohn, Krypt. Fl. Schles. 3^1: 236. 1886

Protomyces graminicola Sacc. Nuovo Giorn. Bot. Ital. **8**: 172. 1876.

Peronospora graminicola Schröter, in Zopf & Sydow, Myc. March. *9*. 1881.

Peronospora graminicola Setariae-italicae Traverso, Bull. Soc. Bot. Ital. **1902**: 168. *f. 1–3*. 1902.

Infesting leaves and inflorescence, causing marked distortion of the latter and, in the case of oöspores, the rapid disintegration of the former; conidiophores 100 × 10–12 μ; conidia 20 × 15–18 μ: oögone-wall thick, 4–12 μ, at maturity 30–60 μ diam., reddish-brown; oöspore pale-brown, 26–36 μ.

The conidiophores of this species are very stout and quite unlike those of any other American species of the order. Their very ephemeral character has caused them to be overlooked by collectors, while the reddish-brown color given to the leaves by the oöspores renders them rather conspicuous objects. As a result herbarium material of this species is rich in oöspores while the conidia are rare. The variety on *Chaetochloa italica* is described as having much larger oöspores than does the typical form, but an examination of American as well as authentic foreign material upon this host failed to show any constant or appreciable difference between the material upon this and upon the other hosts of the species.

ON POACEAE:

Chaetochloa italica (L.) Scribn., Iowa, * *Halsted;* Michigan, *Wheeler;* Wisconsin, * *Pammel.*

Chaetochloa viridis (L.) Scribn., Iowa, *Carver 13*, * *Halsted* (N. Am. Fungi *1803a*), * *Hitchcock*, * *Pammel* (Econ.

Fungi *64*); Minnesota, * *Pammel;* Nebraska, * *Bates* (Fungi Columb. *1776*): South Dakota, * *Griffiths* (W. Am. Fungi *8*); Wisconsin, *Trelease* (N. Am. Fungi *1803b*).

TYPE LOCALITY: Selva, Italy, on *Chaetochloa verticillata* (L.) Scribn.

DISTRIBUTION: Vermont to South Dakota and Kansas. Also in Europe and Asia.

ICONES: Bot. Gaz. **11**: *pl. 8;* Rabenh. Krypt. Fl. ed. 2. **1**^{4}: 438. *f. 71;* Fl. Nebr. **1**: *pl. 16. f. 4;* Berlese, Icon. Fung. Phyc. *pl. 9. f. 1;* Bull. Soc. Bot. Ital. **1902**: 169. *f. 1–3*; Bot. Mag. Tokyo **11**: *pl. 2.*

2. SCLEROSPORA FARLOWII Griffiths, Bull. Torrey Club **34**: 207. 1907

Infected areas on the leaf-sheaths, rarely on the leaf-blades, irregular in outline, usually elongate, brownish with a darker border, up to 10 mm. or more in length; conidiophores unknown; oöspores globose, 28–45 μ; epispore slightly wrinkled, very opaque, reddish-brown, often appearing almost black.

Through the courtesy of Dr. Griffiths, material from the type locality was available for examination. This species is very distinct from *S. graminicola*, from which it differs in the slightly larger and more opaque oöspore with its lighter and smoother epispore. The disintegrating influence of the fungus upon the host is also absent in the present species, while in *S. graminicola* this is very pronounced.

ON POACEAE:

Chloris elegans H. B. K., Arizona, *Griffiths.*

TYPE LOCALITY: Cochise, Arizona, on *Chloris elegans* H. B. K.

DISTRIBUTION: Arizona and Sonora.

Species inquirendae

Three additional species, of which the conidiophores are unknown, have been referred to this genus. The oöspores differ from those of *S. graminicola* in their lighter color, the thinner epispore, the difficulty of freeing them from the tissues of the host in which they are imbedded, and the failure of the affected leaves to liberate the oöspores by the rapid disintegration of the tissues of the host. That these species are members of the present order is doubtful; and if they are, it is still more improbable that they are congeneric with the American species.

S. Magnusiana Sorokin, Rev. Myc. **11**: 143. 1889. On *Equisetum* sp., in the region of the southern Ural Mountains of Russia.

S. macrospora Sacc. Hedwigia **29**: 155. 1890. On *Alopecurus* sp. in Australia, and *Triticum vulgare* L., in Europe.

S. Kriegeriana Magnus, Verh. Deutsch. Naturf. **67**: 100. 1895. On *Phalaris arundinacea* L., in Europe.

4. **RHYSOTHECA** gen. nov.

Peronospora § *Zoosporatoparae* de Bary, Ann. Sci. Nat. IV. **20**: 105. 1863.

Mycelium branching; haustoria simple; condiophores erect, solitary or fasciculate, projecting through the stomata of the host, monopodially branched, the branches usually arising at right angles to the main axis, as do also the secondary branches, at least never appearing truly dichotomous, the ultimate branches apically obtuse; conidia globose to ovoid, hyaline, germinating directly by zoöspores; oöspores yellowish-brown, the epispore variously wrinkled, sometimes appearing somewhat reticulate; oögonium persistent but free from the oöspore. (Etymology, *ῥυσός*, wrinkled, *θήκη*, casket.)

Type species, *Peronospora viticola* (B. & C.) Casp.

To this genus belong the greater number of species which are usually referred to *Plasmopara*. That they are closely related to the preceding genera is evidenced by the habit of branching of the conidiophores and the germination of the conidia by zoöspores. *Plasmopara, sensu stricto*, has conidiophores with the ultimate branchlets apically obtuse as in the present genus, but with the general method of branching more nearly dichotomous than monopodial, and with the conidia germinating in a decidedly anomolous manner. The membrane breaks as in the present genus and the entire protoplasmic content escapes in a mass, forming a non-motile plasma from which a germ-tube is produced. That this is not the typical method of germination either for the *Rhysotheceae* or the *Peronosporeae* is evident, and unless the formation of a plasma be construed as the equivalent of zoöspore-formation the genus cannot stand under the present tribe. That the method of germination is more nearly analogous to that of the *Peronosporeae* is the view held by the present author. The genus *Rhysotheca* is therefore the most highly developed and the typical genus of the group of genera the conidia of which germinates by zoöspores, while *Plasmopara* stands in the same relation to *Peronospora* as does *Pseudoperonospora* to *Rhysotheca*.

Key to the species

- Conidiophores low, averaging 300 μ or less, 2–3 times branched, the branches short. 1. *R. Geranii.*
- Conidiophores tall, averaging over 300 μ, 2–5, usually 4 or 5, times branched, the branches long.
  - Ultimate branchlets elongate, cylindric.
    - Primary branches short, densely branched. 2. *R. Umbelliferarum.*
    - Primary branches elongate, lax.
      - Conidiophores 3–4 times branched.
        - Conidia small, about 15 × 17 μ. 3. *R. Epilobii.*
        - Conidia large, about 27 × 35 μ. 4. *R. Heliocarpi.*
      - Conidiophores 4–5 times branched, very lax. 5. *R. obducens.*
  - Ultimate branchlets more or less conic.
    - Ultimate branchlets broadly truncate.
      - Secondary branchlets very short. 6. *R. Halstedii.*
      - Secondary branchlets lax.
        - Secondary branchlets sparingly branched.
          - Conidia about 12 × 15 μ. 7. *R. australis.*
          - Conidia about 15 × 18 μ. 8. *R. illinoensis.*
        - Secondary branchlets much branched; conidia about 14 × 22 μ. 9. *R. viticola.*
    - Ultimate branchlets narrowly truncate.
      - Conidia elliptic, about 15–20 μ long.
        - Conidiophores 2–4 times branched. 10. *R. Viburni.*
        - Conidiophores 3–5 times branched. 11. *R. ribicola.*
      - Conidia globose-elliptic, about 18–30 μ long. 12. *R. Gonolobi.*

1. **Rhysotheca Geranii** (Peck)

Peronospora Geranii Peck, Rep. N. Y. State Mus. Nat. Hist. **28**: 63. 1876.

Peronospora nivea Geranii Farlow; Ellis, N. Am. Fungi *218*. 1879.

Plasmopara Geranii Berl. & De-Toni, in Sacc. Syll. Fung. **7**: 248. 1888.

Hypophyllous; infected areas conspicuous, definite in outline, or often covering the entire leaf, white-downy; conidiophores fasciculate, monopodially 2–3 times branched, the branches short and with the exception of the lowest rarely with well developed secondary branches, 90–350 × 9–12 μ; conidia obovoid, basally papillate, hyaline, 18–25 × 12–15 μ; oöspores surrounded by periplasm at maturity, 25–35 μ; oögone persistent, wrinkled, yellowish-brown, as is also the epispore.

In Europe two other members of the order occur upon species of *Geranium*, but so far they have not been recorded from America nor has the present species been found abroad. The material issued under this name by Allescher and Schnabel in their Fungi Bavarici *555* is *Plasmopara pusilla*, a much smaller species with almost simple conidiophores. Neither of these species is as large as *Peronospora conglomerata* Fuckel. The mycelium, according to Dr. Halsted,* is perennial.

ON GERANIACEAE:

Geranium carolinianum L., Alabama, *Carver 150*, *Earle*, *Underwood;* Georgia, *Underwood 2242a;* Illinois, *Earle*, *Pammel*, **Seymour* (Fungi Europ. *3176*, N. Am. Fungi *1404*); Indiana, *Arthur*, *Underwood* (Econ. Fungi *A3*, Indiana Fl. *100*); Mississippi, *Tracy;* Missouri, *Galloway*, *Pammel*, *Trelease;* New Jersey, *Ellis*, *Fairchild;* North Carolina, *Stevens.*

Geranium dissectum L., Mississippi, *Tracy* (Fungi Columb. *405*, on "*Geranium carolinianum*").

Geranium maculatum L., District of Columbia, *Galloway 1357;* Indiana, *Olive;* Massachusetts, *Farlow* (N. Am. Fungi *218*); New York, *Jackson 1154*, *Thom;* Ontario, *Dearness* (Fungi Columb. *2048*); West Virginia, *Sheldon;* Wisconsin, *Davis*, *Pammel.*

Geranium pusillum L., Louisiana, *Langlois 942;* South Carolina, *Rolfs 1689.*

? *Geranium Richardsonii* Fisch. & Traut., Wyoming, *Pammel & Stanton.*

This species has also been reported from our limits on *Geranium Robertianum* L.

TYPE LOCALITY: North Greenbush, N. Y., on *Geranium maculatum* L.

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* Bot. Gaz. 15: 321. 1890; 16: 338. 1891.

DISTRIBUTION: Massachusetts to Wyoming, Texas, and Georgia.

ICON: Berlese, Icon. Fung. Phyc. *pl. 12.*

2. **Rhysotheca Umbelliferarum** (Caspary)

Botrytis nivea Mart.; Unger, Exanth. 171. 1833. Not *B. nivea* Mart. 1817.

Botrytis macrospora Ditmar; Unger, Exanth. 173. 1833. Not *B. macrospora* Ditmar 1817.

Peronospora macrocarpa Rabenh. Herb. Viv. Myc. I. *1172.* 1846. Not *P. macrocarpa* Corda 1842.

Peronospora nivea Unger, Bot. Zeit. **5**: 314. 1847. Not *Botrytis nivea* Mart. 1817.

Peronospora macrospora Unger, Bot. Zeit. **5**: 315. 1847. Not *Botrytis macrospora* Ditmar 1817.

Peronospora Conii Tul. Compt. Rend. Acad. Paris **38**: 1103. 1854. (Nomen nudum.)

Peronospora Umbelliferarum Caspary, Monatsb. K. Preuss. Akad. Wiss. **1855**: —(23). 1855.

Plasmopara nivea Schröt. in Cohn, Krypt. Fl. Schles. 3^1: 237. 1886. Not *Botrytis nivea* Mart. 1817.

This species is included by Harkness and Moore in their *Pacific Coast Fungi* as having been collected in the region of San Rafael, Calif., on an undetermined species of *Umbelliferae.* Since then no new record of the species in North America has appeared. That the fungus is rather widely distributed on our continent is not impossible as it infests a wide range of Umbelliferous hosts, several of which are either wild or cultivated in various parts of America. A good illustration of the species is given by Berlese.*

3. **Rhysotheca Epilobii** (Otth)

Peronospora Epilobii Otth, Bern. Mitth. **1868**: 63. 1868.

Plasmopara Epilobii Schröt. in Cohn, Krypt. Fl. Schles. 3^1: 238. 1886.

This species is rather widely distributed in Europe on various species of *Epilobium,* but so far has not been recorded from America. It is illustrated by Berlese.†

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*Icon. Fung. Phyc. *pl. 18.*

†Icon. Fung. Phyc. *pl. 14.*

4. **Rhysotheca Heliocarpi** (Lagerh.)

Plasmopara Heliocarpi Lagerh.; Pat. & Lagerh. Bull. Soc. Myc. France **8**: 123. 1892.

This species is known only from the type locality in Ecuador, where it occurs on the leaves of *Heliocarpus americanus* L. According to Dr. Rose * the host name as given in the original description has been applied very loosely to various members of the Tiliaceous genus *Heliocarpus*, the species of which are widely distributed in tropical America. It is, therefore, not improbable that the fungus is of more than local occurrence and that it infests several hosts.

5. **Rhysotheca obducens** (Schröt.)

Peronospora obducens Schröt. Hedwigia **16**: 129. 1877.

Plasmopara obducens Schröt. in Cohn, Krypt. Fl. Schles. **3**^{1}: 238. 1886.

Peronospora Impatientis Ellis & Everh. Proc. Acad. Nat. Sci. Phila. **1891**: 86. 1891.

Plasmopara Impatientis Berlese, Icon. Fung. Phyc. 15. 1898.

Hypophyllous, usually on the cotyledons, the affected area irregular in outline, following the veins, or covering the entire surface of the leaf, white-cottony; conidiophores fasciculate, 2–4 from a stoma, slender, 300–500 × 7–12 μ, flexuosely branched, the branches usually 4–5 times branched, ultimate branchlets about 6–9 μ long; conidia broadly ellipsoid, 12–14 × 12–21 μ; oöspores light yellowish-brown, 25–30 μ; epispore slightly wrinkled, or smooth; oögone 40–50 μ.

In his monograph Berlese recognizes both *Plasmopara obducens* and *P. Impatientis* as valid species, due apparently to a misinterpretation of the original description of the latter species. In this the height of the unbranched portion only of the conidiophore is given. Otherwise the descriptions of the two species tally as closely as could be expected. Nor is this resemblance accidental, as the type of *Peronospora Impatientis* shows no perceptible points of difference from European material of *P. obducens* which was determined by Schröter himself.

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* Cont. U. S. Nat. Herb. **8**: 315. 1905.

ON BALSAMINACEAE:

Impatiens aurea Muhl., Alabama, *Earle & Underwood;* Indiana, *Arthur*; Iowa, *Holway.*

Impatiens biflora Walt., Connecticut, *Underwood 2981*; Delaware, *Commons* (type of *Peronospora Impatientis* Ellis & Everh.) *Jackson 1572;* District of Columbia, *Williams;* Indiana, *Olive, Underwood, Wilson;* Massachusetts, *Farlow, Halsted & Farlow* (N. Am. Fungi *207*), *Seymour* (Econ. Fungi *A7a*, on "*Impatiens* sp."), *Trelease;* Michigan, *Merrow* (Econ. Fungi *A7b*, on "*Impatiens* sp."); New York, *Dudley & Underwood;* Wisconsin, *Davis, Pammel.*

Impatiens sp., West Virginia, *Sheldon.*

TYPE LOCALITY: Rastatt, Germany, on *Impatiens Nolitangere* L.

DISTRIBUTION: Vermont to Minnesota, southward to Alabama. Also in Europe.

ICON: Berlese, Icon. Fung. Phyc. *pl. 15.*

6. **Rhysotheca Halstedii** (Farl.)

Peronospora Halstedii Farl.; Ellis, N. Am. Fungi *209.* 1879. (Hyponym); Proc. Am. Acad. **18**:72. 1883.

Peronospora Halstedii Ambrosiae Ellis, N. Am. Fungi *210.* 1879. (Hyponym.)

Plasmopara Halstedii Berl. & De-Toni, in Sacc. Syll. Fung. **7**: 242. 1888.

Hypophyllous, on cotyledons and leaves, the affected area small, 1–3 mm., or extending over the entire leaf; conidiophores fasciculate, slender, 300–750 μ, 3–5 times branched, ultimate branchlets 8–15 μ long, verticillate below the apex of the branching axis which is frequently swollen and ganglion-like; conidia oval or elliptic, 18–30 × 14–25 μ; oöspores 30–32 μ; epispore yellowish-brown, somewhat wrinkled.

This is the most unsatisfactory species of a difficult genus. The conidiophores are very variable, especially in the laxity of their branches and the development of the ganglion-like swelling from which the ultimate branchlets arise. Several forms are clearly distinguishable and are apparently valid species, but further search has invariably brought to light intermediate forms connecting the extremes with the typical form and with other forms. Until an exhaustive study of a much greater quantity of material, both conidial and oösporic, is possible than is at present at hand, segregation of this species had best not be attempted. The extreme forms are found on *Eupatorium*, with but few branches with the ganglion-like structure, and on *Helianthus*, where the converse is true.

ON AMBROSIACEAE:

Ambrosia artemisiaefolia L., Iowa, *Arthur*, *Hitchcock;* Massachusetts, *Farlow* (N. Am. Fungi *210*); Missouri, *Demetrio;* Wisconsin, *Pammel.*

Ambrosia psilostachya DC., Kansas, *Bartholomew* (Fungi Columb. *1563*).

Ambrosia trifida L., Kansas, *Kellerman* (N. Am. Fungi *1403d*); New York, *Jackson 1129;* Missouri, *Pammel.*

ON CARDUACEAE:

Bidens cernua L., Vermont, *Grout.*

Bidens frondosa L., Alabama, *Carver 173;* Illinois, *? Pammel;* Indiana, *Wilson;* Iowa, *Arthur*, *Bessey*, *Hitchcock;* Kansas, *Swingle 963;* Michigan, *Merrow* (Econ. Fungi *298*); Mississippi, *Tracy;* Nebraska, *Bates* (Fungi Columb. *2257*); Ontario, *Dearness;* Wisconsin, *Davis*, *Pammel.*

Bidens laevis (L.) B. S. P., Iowa, *Bessey.*

Erechtites hieracifolia (L.) Raf., Illinois, *Waite;* New Jersey, *Halsted* (Econ. Fungi *308 a*); Massachusetts, coll. ign. (Econ. Fungi *308 b*); Wisconsin, *Davis.*

Erigeron annuus (L.) Pers., Wisconsin, *Davis* (as *E. Philadelphicus* Willd.).

Eupatorium ageratoides L. f., Wisconsin, *Pammel.*

Eupatorium purpureum L., Iowa, *Bessey* (N. Am. Fungi *209*); Michigan, *Merrow.*

Gnaphalium spathulatum Lam., Mississippi, *Earle.*

Gnaphalium purpureum L., Alabama, *Atkinson* (Econ. Fungi *314*).

Helianthus annuus L., District of Columbia, *Scribner;* Indiana, *Arthur*, *Thomas;* Ohio, *Kellerman* (Ohio Fungi *68*, on "*Vitis* sp.," later corrected); Ontario, *Dearness* (Fungi Columb. *132*); Wisconsin, *Pammel.*

Helianthus divaricatus L., Wisconsin, *Pammel*, *Trelease.*

Helianthus doronicoides Lam., Iowa, *Arthur;* Kansas, *Kellerman* (Fungi Europ. *3278*, N. Am. Fungi *1403 c*).

Helianthus grosseserratus Martens, Iowa, *Hitchcock, Macbride;* Nebraska, *Sheldon.*

Helianthus hirsutus Raf., Missouri, *Pammel.*

Helianthus Maximiliani Schrad., Iowa, **Pammel.*

Helianthus occidentalis Riddell, Wisconsin, *Pammel.*

Helianthus scaberrimus Ell., Nebraska, *Bates* (Fungi Columb. *2139*).

Helianthus strumosus L., Minnesota, *Arthur;* Wisconsin, *Davis.*

Helianthus tuberosus L., Pennsylvania, *Ellis* (N. Am. Fungi *1403 a*); Wisconsin, *Farlow, Pammel.*

Helianthus sp., New York, *Thom;* Missouri, *Galloway* (on "*Vernonia noveboracensis*"); Wisconsin, *Davis.*

Rudbeckia laciniata L., Nebraska, *Sheldon;* North Dakota, *Seymour;* Wisconsin, *Davis, Pammel.*

Rudbeckia triloba L., Illinois, *Hart.*

Silphium integrifolium Michx., Kansas, *Kellerman* (Fungi Europ. *3279*); Nebraska, *Sheldon;* Wisconsin, *Davis, Pammel.*

Silphium laciniatum L., Iowa, *Arthur.*

Silphium perfoliatum L., Iowa, *Bessey;* Minnesota, *Pammel;* Missouri, *Pammel;* Nebraska, *Sheldon;* Wisconsin, *Davis, Tracy.*

Silphium terebinthinaceum Jacq., Illinois, *Pammel;* Wisconsin, *Davis, Pammel, Trelease* (N. Am. Fungi *1403 b*).

Verbesina encelioides (Cav.) A. Gray, New Mexico, *F. S. & E. S. Earle 172.*

The following additional hosts are reported from our limits: *Artemisia ludoviciana* Nutt., *Bidens comosa* (A. Gray) Wiegand, *B. connata* Muhl., *Centaurea* sp., *Helianthus trachaelifolius* Willd., *Iva xanthiifolia* (Fres.) Nutt., *Madia sativa* Molina, *Silphium trifoliatum* L., *Solidago canadensis* L., *S. Riddellii* Frank, *Vernonia Baldwinii* Torr., *V. noveboracensis* (L.) Michx., and *Xanthium canadensis* Mill. Of these two are somewhat doubtful, as it is quite probable that the record of *Iva* as a host refers to *Basidiophora Kellermanii*, while a part of the material which served as the basis for the citation of *Vernonia noveboracensis* as a host has been examined and instead of that species the host is some *Helianthus*, but as the leaves seen were all very young it is impossible to determine the species.

TYPE LOCALITY: Jamaica Plain, Massachusetts, on *Eupatorium purpureum* L.

DISTRIBUTION: Vermont to North Dakota, California, and Alabama. Also in Europe.

ICONES: Fl. Nebr. **1**: *pl. 16. f. 5;* Berlese, Icon. Fung. Phyc. *pl. 20.*

7. **Rhysotheca australis** (Speg.)

Peronospora australis Speg. Anal. Soc. Ci. Argent. **12**: 36. 1881.
Peronospora sicyicola Trel.; Farlow, Bot. Gaz. **8**: 331. 1883.
Plasmopara australis Swing. Trans. Kan. Acad. Sci. **11**: 72. 1889.

Hypophyllous, the infected area amphigenously discolored, of variable size and shape, bounded by leaf-veins; conidiophores fasciculate, arising from the stomata of the host, 500–650 × 9–11 μ, with 5–7 main branches, the branches monopodially 3–4 times branched, the ultimate branchlets 10–14 μ long; conidia widely ellipsoid, 14–17 × 10–13 μ; mature oöspores unknown.

This species is very distinct in habit as well as in other important characters from *Pseudoperonospora cubensis*, with which European mycologists have sometimes confused it. The mature oöspores are unknown, but the immature ones are described as almost hyaline and with a smooth epispore, 30–40 μ.*

ON CUCURBITACEAE:

Micrampelis lobata (Michx.) A. Gray, Kansas, *Bartholomew* (Fungi Columb. *2334*).

Sicyos angulatus L., Illinois, *Clinton, Pammel, Seymour* (Econ. Fungi *42*, Fungi Europ. *3276b*); Indiana, *Olive, Wilson*; Kansas, *Kellerman* (Fungi Europ. *3276a*); Missouri, *Galloway;* Nebraska, *Bartholomew* (Fungi Columb. *2556*); New York, *Jackson 1150, Thom;* Ohio, *Kellerman* (Ohio Fungi *147*); Ontario, *Dearness;* Wisconsin, *Pammel, Trelease* (Fungi Gallici *3421*, N. Am. Fungi *1416*).

TYPE LOCALITY: Recoleta, Argentina, on *Cyclanthera Hystrix* Arn.

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* Swingle, *l. c.*

DISTRIBUTION: Massachusetts to Ontario, Wisconsin, Kansas, and Ohio. Also in South America.

ICONES: Rep. Mass. State Agr. Exp. Sta. **8**: *pl. 2. f. 15, 16*; Rev. Myc. **22**: *pl. 203. f. 10, 11*; Berlese. Icon. Fung. Phyc. *pl. 16*.

8. **Rhysotheca illinoensis** (Farl.)

Peronospora illinoensis Farl. Bot. Gaz. **8**: 332. 1883.

Hypophyllous; infected area irregular in outline, up to 10 mm., densely cottony, epiphyllous discoloration slight or none; conidiophores fasciculate, about 500 × 10 μ, with 2–4 main branches which are 2–4 times laxly branched, the ultimate branchlets 10–12 μ long, subacute; conidia elliptic, 15–18 × 17–20 μ; oöspores unknown.

This species is known only from the collections of Professor Seymour at Camp Point and Quincy, Illinois. The inconspicuous habit of the fungus and the wide distribution of the host make it very probable that the species will be found to have a much wider range than now known. European botanists have excluded the species from the genus.* Through the kindness of the authorities of the University of Illinois I have been permitted to examine material of the species. It is nearest to *R. australis*, but with much more irregularly branched and more flexuose conidiophores, which at first sight suggest those of *Pseudoperonospora Celtidis*.

ON URTICACEAE:

Parietaria pennsylvanica L., Illinois, *Seymour 5302, 5354, 5355*.

TYPE LOCALITY: Southern Illinois, on *Parietaria pennsylvanica* L.

DISTRIBUTION: Illinois.

9. **Rhysotheca viticola** (B. & C.)

Botrytis viticola B. & C.; Berkeley, Jour. Hort. Soc. Lond. **6**: 289. 1851. (Hyponym.)

Botrytis vitis-viticola B. & C.; Taylor, Ann. Rep. U. S. Dep. Agr. **1871**: 110. 1872. (Hyponym.)

Peronospora viticola Caspary, Monatsb. K. Preuss. Akad. Wiss. **1855**: 331. 1855. (Hyponym); de Bary, Ann. Sci. Nat. IV. **20**: 125. 1863.

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* A. Fischer; Rabenh. Krypt. Fl. ed. 2. 4^1: 485. 1892. — Berlese, Icon. Fung. Phyc. 41. 1898.

Plasmopara viticola Berl. & De-Toni, in Sacc. Syll. Fung. **7**: 338. 1888.

Hypophyllous, caulicolous, or on young fruits, covering the host with a white downy growth, or causing a brown rot of the fruit without producing aerial hyphae; conidiophores fasciculate, 250–850 x 5–8 μ, 4–5 times branched, the ultimate branchlets about 8 μ long; conidia elliptic-ovate, very variable in size, 9–12 x 12–30 μ; oöspores 30–35 μ; epispore brown, wrinkled, or almost smooth: oögone thin-walled, hyaline or light yellowish-brown.

This is one of the worst fungous pests of the vineyard. It was first collected in the United States by Schweinitz in 1834, and referred to *Botrytis cana* Link. Later Ravenel, Curtiss, and others sent material from South Carolina and New England to Berkeley and de Bary. The first published account of the species which has come to our notice is by Berkeley, who, in publishing a translation of one of Léveillé's papers upon the *Oidium* of the vine, remarks that "a true *Botrytis* of the same section with *Botrytis infestans** but far more beautiful, and highly developed, occurs in South Carolina on vine leaves. I have not, however, heard that it is injurious. My specimens. which were gathered by Mr. Ravenel, and have been named *B. viticola* Berk. and Curt., occurred on *Vitis aestivalis*, and, I believe, on some other species."†

In more recent years mycologists of this and other countries have experienced a decided change of opinion as to the injurious character of the disease. Berlese ‡ estimates that 75 per cent. of the crop is destroyed in the northern states by this disease. That this is as extreme a view as the one previously quoted is not improbable, yet that great injury, especially to some varieties, is due to this fungus is certain. The most destructive form is that which occurs on the fruits as a brown rot.

ON VITACEAE:

Parthenocissus quinquefolia (L.) Planch., Alabama, *Underwood*; Minnesota, *Farlow* (N. Am. Fungi *1402*, on "*Ampelopsis quinquefolia*"), *Seymour*; New York *Jackson*, *1124*.

**Phytophthora infestans* (Mont.) de Bary.

† Jour. Hort. Soc. London **6**: 289, note. 1851.

‡ Riv. Pat. Veg. **9**: 102. 1902.

Parthenocissus tricuspidata (Sieb. & Zucc.) Planch., New Jersey, *Halsted* (N. Am. Fungi *2427 b*, on "*Ampelopsis Ritchii*," error for the horticultural name *A. Veitchii*).

Vitis aestivalis Michx., Indiana, *Arthur;* Massachusetts, *Grout;* South Carolina, *Ravenel* (Fungi Am. Exs. *61*; Myc. Univ. *617*, on "*V. vinifera*" but subsequently corrected; Fungi Carol. 5: *90*).

Vitis bicolor Le Conte, New York, *Long.*

Vitis californica Benth., California, *Harkness* (N. Am. Fungi *2247a*).

Vitis cinerea Engelm., Illinois, *Pammel.*

Vitis cordifolia Michx., Indiana, *Olive;* Illinois, *Earle, Hart, Waite;* Missouri, *Jaeger, Trelease;* New York, *Underwood;* Ohio, *Aiken* (Phyc. Prot. *122*); Wisconsin, *Pammel.*

Vitis labrusca L., Connecticut, *Sheldon;* District of Columbia, *Scribner, Williams;* Iowa, *Buchanan, Griffin, Pammel, Stewart, Rolfs, Macbride;* Kansas, *Kellerman* (Funghi Par. Piant. Colt. *102*, on "*Vitis Concord*"; Roum. Fungi Sel. Exs. *5517*, on "*Vitis* cultive var. (*Concord*)"); Massachusetts, *Farlow* (N. Am. Fungi *208*, on "*Vitis* cult."), *Seymour* (Econ. Fungi *3*, on "*Vitis* sp. cult."), *Underwood;* New York, *Blodgett;* Ohio, *Kellerman* (Ohio Fungi *169a*, on "*Vitis* sp. cult."); Pennsylvania, *Ellis;* Wisconsin, *Henry, Pammel, Trelease, Underwood.*

Vitis rotundifolia Michx., Michigan, *Merrow* (Econ. Fungi *3a*, on "*Vitis* sp.").

Vitis vulpina L., Iowa, *Arthur, Hitchcock;* Kansas, *Bartholomew* (Fungi Columb. *2345*); New York, *Jackson 1120, Stevens* (Fungi Columb. *545*, on "*Vitis riparia*"); Ohio, *Kellerman* (Ohio Fungi *169b*); West Virginia, *Sheldon;* Wisconsin, *Clinton, Pammel.*

An additional host, *Vitis vinifera* L., is reported from North America.

TYPE LOCALITY: South Carolina, on *Vitis aestivalis* Michx.

DISTRIBUTION: Coextensive with the grape (*Vitis* spp.) throughout the world.

ICONES: Rep. U. S. Dep. Agr. **1871** : *pl. 4;* Bull. Bussey Inst. **1** : *pl. 2. f. 1, pl. 3. f. 2–8;* Bull. Ill. Lab. Nat. Hist, **1**^{1} : *Par. Fungi pl. 2. f. 6, 7;* Rep. U. S. Dep. Agr. **1886** : *Mycol. pl. 1;* Berlese, Icon. Fung. Phyc. *pl. 17, 18.*

10. **Rhysotheca Viburni** (Peck)

Plasmopara Viburni Peck, Rep. N. Y. State Mus. Nat. Hist. **43** : 74. 1890.

Hypophyllous, affected areas irregular in outline, 3–10 mm. in diam., marginal or following the larger veins, sparingly white-downy, epiphyllous discoloration none to dark reddish-brown or chocolate-colored; conidiophores fasciculate, sparingly 2–3, rarely 4 times branched, 300–600 x 6–8 μ, ultimate branchlets 6–8 μ; conidia broadly elliptic, rarely globose, 15–30 x 12–15 μ, or larger; oöspores unknown.

The present species and the two following ones form a distinct group, and are very closely related; all of them are poorly understood and by no means common in collections. The present species is especially close to *R. ribicola*, from which it differs in its taller conidiophores, its sparser covering and more pronounced discoloration of the host.

ON CAPRIFOLIACEAE:

Viburnum acerifolium L., District of Columbia, *Waite;* West Virginia, *Waite.*

Viburnum dentatum L., New York, *Peck* (cotype), *Thom.*

Viburnum nudum L., Alabama, *Earle* (Phyc. Prot. *81*).

Viburnum Opulus L., Maryland, *Fairchild.*

Viburnum pubescens (Ait.) Pursh, West Virginia, *Waite 721.*

TYPE LOCALITY: Baiting Hollow Station, Long Island, N. Y., on *Viburnum dentatum* L.

DISTRIBUTION: Central New York to Alabama.

11. **Rhysotheca ribicola** (Schröt.)

Peronospora ribicola Schröt., Jahrb. Schles. Ges. Vaterl. Kult. **1883**: 139. 1883.

Plasmopara ribicola Schröt. in Cohn, Krypt. Fl. Schles. **3**^{1}: 238. 1886.

Hypophyllous, infected area usually near the main veins, irregular in outline, up to 15 mm., loosely downy, epiphyllous discoloration light and usually not pronounced; conidiophores fasciculate, 200–400 × 7–9 μ, 3–5 times branched, ultimate branchlets 4–8 μ long; conidia elliptic to globose-elliptic, 14–22 × 10–14 μ; oöspores unknown.

This is one of the rarest species of the genus. It is distinguishable from the preceding species by its more conspicuous habit of growth, the smaller conidiophores, and the less pronounced discoloration of the host.

ON GROSSULARIACEAE:

Ribes albinervum Michx., Wisconsin, *Davis* (Fungi Columb. *1753*, on "*Ribes rubrum subglandulosum* Maxim.").

Ribes divaricatum Dougl., Washington, *Piper 2957*.

Ribes hirtellum Michx., Wisconsin, *Davis* (on "*Ribes oxyacanthoides* L.").

Ribes prostratum L'Her., Wisconsin, *Davis*.

Ribes rotundifolium Michx., West Virginia, *Sheldon*.

TYPE LOCALITY, Liegnitz, Germany, on *Ribes rubrum* L.

DISTRIBUTION: West Virginia to Washington. Also in Europe.

12. **Rhysotheca Gonolobi** (Lagerh.)

Peronospora Gonolobi Lagerh. Jour. Myc. 7: 49. 1891.
Plasmopara Gonolobi Swingle, Jour. Myc. 7: 119. 1892.
Plasmopara Vincetoxici Ellis & Everh. Jour. Myc. 8: 70. 1902.

Hypophyllous, infected area about 2–5 mm. bounded by the veins, rather well covered with conidiophores, epiphyllous discoloration light-brown; conidiophores fasciculate, 300–600 × 8–10 μ, 4–6 times branched, ultimate branchlets 6–10 μ long; conidia globose-elliptic, rarely elliptic, 16–25 × 13–24 μ, or even larger; "oöspores globose, brown, about 20 μ diam."

The type material of *Peronospora Gonolobi* was collected by Dr. J. H. Mellichamp and sent to Dr. Farlow, who distributed the collection for *Pucinia Gonolobi* Rav., the predominating parasite on the material, and so far as some of the specimens are concerned the only one. Among these latter is the one in the Ellis herbarium. It was, however, possible to determine positively the species of the host which was cited by Lagerheim as *Gonolobus* sp. but which is in reality *Vincetoxicum hirsutum*. The host of *Plasmopara Vincetoxici* is also the same species. This discovery led to the conclusion that the two species were the same, a conclusion which has since been borne out by an examination of authentic material of the earlier species. The present species is easily distinguished from either of the two preceding ones by its larger conidia and more complexly branched conidiophores.

ON ASCLEPIADACEAE:

Vincetoxicum hirsutum (Michx.) Britton, Alabama, *Carver 932.* (Type of *Plasmopara Vincetoxici.*)

Vincetoxicum suberosum (L.) Britton, Florida, *McCulloch.*

An additional host, *V. gonocarpos* Walt., is also recorded.

TYPE LOCALITY: Blufton, South Carolina, on *Gonolobus* sp. (= *Vincetoxicum hirsutum* (Michx.) Britton).

DISTRIBUTION: Maryland to Florida and Mississippi.

5. PSEUDOPERONOSPORA Rostew. Ann. Inst. Agron. Moscou 9: 47. Ja 1903. — Flora 92: 422. O 1903

Plasmopara § *Peronoplasmopara* Berl. Riv. Pat. Veg. 9: 122. 1901.

Peronoplasmopara Clinton, Rep. Conn. State Agr. Exp. Sta. 29: 234. 1905.

Mycelium intracellular, branching, haustoria small, usually simple; conidiophores pseudo-monopodially branched, the primary branches arising, as a rule, at acute angles, the ultimate branchlets acute; conidia typically colored, rarely hyaline, elliptic in outline, conspiciously papillate both apically and basally; oöspores thin-walled, smooth or roughened; oögone thin-walled.

Type species, *Peronospora cubensis* B. & C.

The present genus is the most anomalous of the tribe, combining as it does certain characteristics of the present and succeeding tribes. The conidia germinate, as in all species of the *Rysotheceae*, by zoöspores, while the colored conidia suggest a close relationship with *Peronospora.* This is further augmented by the apically acute conidiophores, the method of branching of which is intermediate between the typical method of the two tribes in question.

The close relationship of the two species to each other and their problematical taxonomic position was pointed out by Waite at the time he described the second one.* He, however, allowed them to remain in the genus *Peronospora.* The next step was taken by Berlese, who formed for them a subgenus under the old genus *Plasmopara,* which he characterized as having the conidiophores of *Peronospora* and the conidia of *Plasmopara, i. e. Rhysotheca* of the present treatment of the group. The final step was taken by Rostewzew who made an extensive study of *P. cubensis,* the results of which appeared in an elaborate paper which was published first in Russian and later in German. He concluded that this species represented a distinct genus intermediate between *Peronospora* and *Plasmopara, sensu* Schröter. He called the genus *Pseudoperonospora,* choosing this name, as he tells us, rather than *Pseudoplasmopara* as *Peronospora* antedates *Plasmopara.* Later Dr. Clinton made an extended study of the species in America, publishing an admirable paper upon his researches. Unfortunately, at least from a nomenclatural standpoint, he rejected the earlier generic name in favor of Berlese's subgeneric name, and still more unfortunately he has been followed in this by other American mycologists. The name proposed by Rostewzew has more than two years priority over the elevation of Berlese's subgenus to generic rank, and is therefore the rightful name of the genus.

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* Jour. Myc. 7: 105. 1892.

Key to the species

Conidiophores 3–4 times branched.	1. *P. cubensis.*
Condiophores 4–5 times branched.	2. *P. Celtidis.*

1. PSEUDOPERONOSPORA CUBENSIS (B. & C.) Rostew.
Ann. Inst. Agron. Moscou **9**: 47. Ja 1903. —
Flora **92**: 422. O 1903

Peronospora cubensis B. & C. Jour. Linn. Soc. Bot. **10**: 363. 1868.

Plasmopara cubensis Humphrey, Rep. Mass. State Agr. Exp. Sta. **8**: 212. 1891.

Peronoplasmopara cubensis Clinton, Rep. Conn. Agr. Exp. Sta. **1904**: 335. 1905.

Hypophyllous, or rarely amphigenous; discoloration of the host yellowish, rather definite in outline, affected area apparently unoccupied or with a sparse marginal growth; condiophores 1–2, rarely more, from a stoma, 180–400 x 5–9 μ, 3–4, rarely 2–5, times branched, the ultimate branchlets recurved, apically acute, 5–20 μ long; conidia gray, brownish or smoky, ovoid to ellipsoid, papillate, 20–40 × 14–25 μ; oöspores spherical, yellowish, watery-papillate, 30–43 μ, maturing in the decaying leaves.

This is one of the most important pests of the truck farmer. Its adaptibility to almost any cultivated species of *Cucurbitaceae* and the comparative immunity of the native species, especially in the more northern states, makes it a pest which is most destructive in regions where Cucurbitaceous vegetables are cultivated in commercial quantities. Its favorite hosts appear to be the cucumber and melon. It has been suggested that the fungus spreads from south to north each season, and in proof of this theory are cited the perennial character of the mycelium in Florida and the records of the distribution of the pest in the southern and eastern states in recent years.* It has also been suggested that hot-house culture of the hosts assists in scattering the disease, at least in the immediate vicinity. It is not impossible that both these factors enter into the distribution of the fungus, while the researches of Rostewzew, who found the immature oöspores in the partially decayed leaves of infested vines, tend to establish the probability that oöspore-production also plays a most important part in the persistency of the pest in infested areas. By the first two means suggested, the distribution of the fungus would of necessity be confined to those regions which could be reached by summer migration and in which hot-house cucurbits were produced. The third method of passing the winter, in addition to the first two, accounts for the occurrence and persistence of the disease in places which, according to the two preceding theories, should be immune from the pest. The problem presented is one of great scientific interest and of a not inconsiderable financial importance to certain sections of the country.

ON CUCURBITACEAE:

Bryonopsis lacunosa erythrocarpa Naud., Ohio, *Selby.*
Citrullus vulgaris Schrad., Louisiana; *Langlois 1122.*
Coccinia indica Wright & Arn., Ohio, *Selby.*
Cucumis angulatus Forsk., Ohio, *Selby.*
Cucumis Melo L., Ohio, *Selby.*
Cucumis odoratissimus Moench, Ohio, *Selby.*

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* Bull. S. Car. Agr. Exp. Sta. 116: 7. 1905.

Cucumis sativus L., Florida, *Hume 24;* Massachusetts, *Humphrey;* New Jersey, *Halsted* (N. Am. Fungi *2426a;* Econ. Fungi *41*), *Stevens;* Maryland, *Dorsett;* Ohio, *Selby* (Phyc. Prot. *119*); West Virginia, *Sheldon.*

? *Cucurbita maxima* Duch., New Jersey, *Halsted* (N. Am. Fungi *2426b*).

Cucurbita ovifera L., Ohio, *Duvel.*

Cucurbita Pepo L., Ohio, *Duvel.*

Lagenaria vulgaris Ser., Ohio, *Duvel.*

Micrampelis lobata (Michx.) Greene, Ohio, *Selby.*

Momordica balsamina L., Iowa, *Arthur.*

Mukia scabrella Arn., Ohio, *Duvel.*

The following additional hosts are reported from within our limits: *Cucumis Anguria* L., *Melothria scabra* Naud., *Momordica charantia* L., *Sicyos angulatus* L., *Trichosanthes colubrina* Jacq.

TYPE LOCALITY: Cuba, on some unidentified species of *Cucurbitaceae.*

DISTRIBUTION: New Hampshire to Minnesota, Texas, Florida, and Cuba. Also in South America, Europe, Asia, and Africa.

ICONES: Riv. Pat. Veg. **9**: 125. *f. 21;* Rep. Mass. State Agr. Exp. Sta. **8**: *pl. 2. f. 11–14;* Bull. Ohio Agr. Exp. Sta. 89: *pl. 1;* Rep. Fla. Agr. Exp. Sta. **1899–00**: *pl. 1;* Rev. Myc. **22**: *pl. 203. f. 7–9;* Rep. Conn. Agr. Exp. Sta. **1904**: *pl. 31.*

2. **Pseudoperonospora Celtidis** (Waite)

Peronospora Celtidis Waite, Jour. Myc. **7**: 105. 1892.

Plasmopara Celtidis Berlese, Icon. Fung. Phyc. 16. 1898.

Peronoplasmopara Celtidis Clinton, Rep. Conn. Agr. Exp. Sta. **1904**: 334. 1905.

Hypophyllous, infected areas brownish, limited by the veins, from less than 1 mm. up to covering a large portion of the leaf; epiphyllous discoloration purple with a more or less pronounced yellowish margin; conidiophores scattered, 200–320 × 6–8 μ, 4–5 times branched, the ultimate branchlets straight or slightly recurved, about 5–8 μ long; conidia elliptic, 12–26 × 20–40 μ, smoky or somewhat purplish; oöspores in the leaves, 26–45 μ; epispore thin, yellowish-brown, irregularly thickened; oögone persistent, thin-walled, smooth.

This species is remarkable as the only member of the order which infests a tree, although a few species occur on shrubs. Perhaps this unusual habitat accounts for the rarity of the species in herbaria.

ON ULMACEAE:

Celtis occidentalis L., District of Columbia,* *Waite 556, 557*.

TYPE LOCALITY: Washington D. C., on *Celtis occidentalis* L.

DISTRIBUTION: Maryland and District of Columbia.

ICON: Jour. Myc. 7: *pl. 17. f. 1–16*.

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Vol. 22, part 2, issued December 18, 1905, contains descriptions of the families Saxifragaceae and Hydrangeaceae by Dr. J. K. Small and Dr. P. A. Rydberg; the Cunoniaceae, Iteaceae and Hamamelidaceae by Dr. N. L. Britton; the Pterostemonaceae by Dr. J. K. Small; the Altingiaceae by Percy Wilson and the Phyllonomaceae by Dr. H. H. Rusby.

Vol. 7, part 1, issued Oct. 4, 1906, contains descriptions of the families Ustilaginaceae and Tilletiaceae, by Professor G. P. Clinton.

Vol. 7, part 2, issued March 6, 1907, contains descriptions of the families Coleosporiaceae, Uredinaceae and Aecidiaceae (pars), by Professor J. C. Arthur.

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CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
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STUDIES ON THE ROCKY MOUNTAIN FLORA—XVIII

By PER AXEL RYDBERG

NEW YORK
1907

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 34: 417–437. 1907]

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Studies on the Rocky Mountain flora—XVIII

PER AXEL RYDBERG

Homalobus divergens (Blankinship) Rydb.

Astragalus divergens Blankinship, Mont. Agric. Coll. Sci. Stud. Bot. **1**: 73. 1905.

Homalobus camporum Rydb. Bull. Torrey Club **32**: 666. 1906.

When I described *Homalobus camporum* I overlooked the facts that the same species had already been published by Prof. Blankinship and that he had even cited the type number of my type. He had described the pod, however, as having a stipe, something that I cannot find in any specimens at hand.

Homalobus humilis sp. nov.

Perennial with a cespitose caudex; stems 2–10 cm. long, grayish-strigose, decumbent or spreading; stipules ovate, scarious, 2–3 mm. long; leaves 2–6 cm. long; leaflets 11–15, oblong, 3–6 mm. long, about 2 mm. wide, grayish-strigose beneath, glabrate above; peduncles 2–8 cm. long; raceme short, 1–2 cm. long, 3–8-flowered; calyx strigose with black hairs; tube campanulate, 1.5–2 mm. long; teeth triangular or triangular-subulate, 1–1.5 mm. long; corolla purple, 7–8 mm. long; legume about 1.5 cm. long, 3 mm. wide, widest near the abruptly acute apex, tapering towards the base, the upper suture nearly straight, the lower strongly arched at the apex.

This species most resembles *H. divergens* (Blankinship) Rydb. in habit, but differs in the shape of the legumes, the darker corollas, and in the less canescent leaves, which are glabrate above. It grows on high arid mountain tops at an altitude of nearly 3,000 m.

UTAH: Mountain north of Bullion Creek, near Marysvale, 1905, *Rydberg & Carlton 7147* (type); Delano Peak, 1905, *nos. 1219* and *1219 a*.

Homalobus microcarpus sp. nov.

Homalobus campestris Rydb. Bull. Agr. Exp. Sta. Col. **100**: 209, in part. 1906. Not *H. campestris* Nutt.

Homalobus camporum Rydb. *loc. cit.*, in part.

Perennial with a cespitose caudex; stems decumbent, about 1 dm. high, strigose; leaves 5–8 cm. long; stipules ovate, scarious, 2–3 mm. long; leaflets 9–15, elliptic to linear, 5–15 mm. long, 1–3 mm. wide, glabrous above, sparingly strigose beneath; peduncles 4–6 cm. long; racemes short, 3–8-flowered; calyx strigose with black hairs; tube campanulate, about 2 mm. long; teeth about 1 mm. long, subulate; pod sessile, strigose, straight, 12–18 mm. long, 3 mm. wide.

This species is intermediate between *H. oblongifolius* Rydb. and *H. divergens* (Blankinship) Rydb. Baker's specimens from North Park were referred to the latter, which the present species resembles in general habit and the pod; but it is a greener plant, the leaflets being glabrous above and only slightly strigose beneath. The smaller size, and the smaller pod of a different shape, separate it from *H. oblongifolius*.

COLORADO: East slope of Rabbit Ear Range, 1894 (type distributed from the State Agricultural College of Colorado, collector not given); Forks of Poudre and Big South, 1894; North Park, 1897, *C. F. Baker;* Steamboat Springs, 1903, *Osterhout 2774.*

Homalobus paucijugus sp. nov.

Perennial with a cespitose caudex, bushy; stems 1–2 dm. high, sparingly strigose; leaves numerous, 5–10 cm. long; leaflets 1–5, the lateral ones lanceolate to linear-subulate, 1 cm. or less long, glabrous above, sparingly strigose beneath, or none; the terminal one 1–2 cm. long, linear or linear-oblanceolate, gradually tapering into the rachis; stipules scarious, ovate, 2–3 mm. long; peduncles 3–6 cm. long; racemes short, 3–6-flowered; calyx strigose with black hairs; tube campanulate, about 2 mm. long; teeth subulate, fully 1 mm. long; legume 12–15 mm. long, 2 mm. wide, straight, strigose.

This species resembles *H. decurrens* in the peculiar terminal leaflet, but differs in the few small and narrow lateral leaflets, the small size of the plant, the small flowers and the small pod. It grows at an altitude of nearly 3000 m.

UTAH: Big Cottonwood Cañon, in sheltered places near the summit of the divide between Lake Solitude and Twin Lakes, 1905, *A. O. Garrett 1580.*

The species confused with *H. tenellus* and usually included in it may be distinguished by the following characters:

Legume glabrous.
- Stipe rarely exceeding the tube of the calyx; leaves usually spreading in age; leaflets oblong to oval, obtuse and mucronate. *H. dispar.*
- Stipe of the mature legume usually exceeding the calyx-teeth; leaves strongly ascending; leaflets narrowly linear to linear-oblong, mostly acute.
  - Stipe 3–4 mm. long; leaflets linear or linear-oblong; stem usually conspicuously strigose; calyx-teeth half as long as the tube. *H. tenellus.*
  - Stipe 5–7 mm. long; leaflets narrowly linear; stem glabrous or nearly so; calyx-teeth usually nearly equaling the tube. *H. stipitatus.*

Legume strigose. *H. strigulosus.*

HOMALOBUS DISPAR Nutt.; T. & G. Fl. N. Am. 1: 350. 1838.

Orobus dispar Nutt. Gen. 2: 95. 1818.

This is much less common and has a more restricted range than *H. tenellus.* The range of *H. dispar* includes the extreme western portion of Nebraska, Wyoming, northern Colorado and northeastern Utah, while that of *H. tenellus* extends from Saskatchewan to Nebraska, Colorado, Utah, and the Yukon Territory.

Homalobus stipitatus sp. nov.

Somewhat cespitose perennial; stems slender, 3–4 dm. high, erect, branched, sparingly strigose or glabrate, leafy; leaves strongly ascending, 4–6 cm. long; stipules lance-subulate; leaflets 9–15, narrowly linear, 1–2 cm. long, 1–2.5 mm. wide, glabrous or sparingly strigose beneath; peduncles about 1 cm. long; racemes lax, 2–10 cm. long, 5–20-flowered; calyx strigose; tube campanulate, about 1.5 mm. long; teeth subulate, about as long; corolla ochroleucous, 8–10 mm. long; legume glabrous, stipitate, flat; body oblong, about 1 cm. long, 3 mm. wide, acute, gradually tapering into the stipe, which is 5–7 mm. long.

This species is related to *H. tenellus* (Pursh) Britton [*Astragalus multiflorus* (Pursh) A. Gray], but is a more slender and more glabrate plant, with narrower leaflets and longer stipe. It belongs to the prairie region east of the range occupied by *H. tenellus.*

NORTH DAKOTA: "Upper Missouri" [from the data given in Nicollet's report, on the hills somewhere between Fort Pierre and Devil's Lake], 1839, *Geyer* (type in herb. Columbia University); Valley City, 1897, *L. L. Perrine.*

MINNESOTA: Lake Belmont, Otter Tail Co., 1892, *E. P. Sheldon.*

SASKATCHEWAN: 1858, *E. Bourgeau 4.*

Homalobus strigulosus sp. nov.

Cespitose perennial; stems erect or ascending, branched, 1–3 dm. high, strigulose; stipules short, ovate; leaves 3–4 cm. long; leaflets linear, acute, 8–12 mm. long, 1–2 mm. wide, thick, glabrous above, strigose beneath; peduncles 1 cm. or less; raceme lax, 1.5–3 cm. long, 4–7-flowered; bracts minute, subulate; calyx strigulose; tube campanulate, 1.5 mm. long; teeth subulate, less than 1 mm. long; corolla ochroleucous, about 6 mm. long; pod strigose, shining, stipitate; body oblong, 7–8 mm. long, 3 mm. wide, rather gradually contracted into the stipe, which is about 3 mm. long.

This is closely related to *H. tenellus*, but differs in the smaller flowers and the smaller and hairy pod. It grows at an altitude from 1800–3000 m.

NEVADA: East Humboldt Mountains, 1860, *S. Watson 283* (type).

UTAH: P. V. Junction, Wasatch Mountains, 1883, *M. E. Jones* (mixed with *H. tenellus*).

Diholcos micranthus sp. nov.

Somewhat cespitose perennial; stems erect or ascending, sparingly strigose or glabrate, 2–4 dm. high; stipules ovate, about 5 mm. long; leaves 4–6 cm. long; leaflets 17–25, linear or lance-oblong, acute at both ends, 7–20 mm. long, glabrous above, strigose beneath; peduncles 4–7 cm. long; racemes many-flowered, 3–7 cm. long; calyx strigose; tube campanulate, slightly gibbous, 2–2.5 mm. long; teeth subulate-filiform, 1–2 mm. long, the upper somewhat shorter; corolla 6–7 mm. long, ochroleucous; pod strigose, obsoletely if. at all cross-ribbed; stipe 3–4 mm. long; body scarcely 1 cm. long, 3 mm. wide, very acute.

This species is related to *D. Haydenianus* (A. Gray) Rydb. [*Astragalus Haydenianus* A. Gray], differing in the smaller flowers and fruit, the more acute leaflets, the narrower calyx-lobes, and especially the almost total lack of cross-ribs on the more acute legumes. *D. micranthus* was included in *D. Haydenianus* in my Flora of Colorado.

COLORADO: La Veta, 1896, *C. L. Shear 3569* (type); Gunnison, 1896, *Clements 100;* Ridgeway, 1895, *Tweedy 228;* Rio Blanco, south of Pagosa, 1883, *B. H. Smith.*

Kentrophyta minima sp. nov.

Perennial with a woody root and cespitose caudex, forming cushions 1 dm. in diameter; herbaceous stems 1–2 cm. high;

leaves 5–8 mm. long; stipules scarious, lanceolate, 1–3 mm. long, more or less united; leaflets 5–9, linear-lanceolate, conduplicate, pungent, 3–4 mm. long, finely strigose; flowers usually solitary, subsessile; calyx strigose; tube 1–1.5 mm. long, campanulate; teeth subulate, scarcely 1 mm. long; corolla ochroleucous, about 3 mm. long; keel tipped with purple; pod ovoid, rather turgid, acute, 3 mm. long.

This is related to **K. tegetaria** (S. Wats) Rydb. [*Astragalus tegetarius* S. Wats.] and *K. Wolfii* Rydb. From the former it differs in the subsessile flowers and the shorter calyx-lobes; *K. tegetaria* has 1–3-flowered racemes, exceeding the leaves in length and calyx-lobes which are longer than the tube. From *K. Wolfii*, it differs in the appressed pubescence, the smaller flowers and the shorter legume. It is an alpine species growing at an altitude of 2800–3100 m.

YELLOWSTONE NATIONAL PARK: August 1884, *Tweedy 83* (herb. Columbia Univ.).

Aragallus patens sp. nov.

Acaulescent perennial; leaves spreading or ascending, 5–10 cm. long; leaflets 9–17, elliptic or oblong, acutish at both ends, 1–2 cm. long, 4–6 mm. wide, somewhat silvery with closely appressed hairs; scape 1–1.5 dm. high, strigose with short silky hairs; raceme short, 3–7 cm. long; bracts linear-lanceolate to lanceolate, 5–8 mm. long; flowers usually spreading; calyx sparingly appressed-silky with short hairs, often somewhat tinged with purple above, 5–6 mm. long, 3 mm. wide; teeth subulate, the upper 2 mm., the lower 3 mm. long; corolla dark bluish-purple, about 15 mm. long; banner narrow; wings broad, slightly emarginate, the upper lobes narrow and acutish; keel with a very dark purple spot, and a short, porrect tip; legume ascending-spreading, thin-coriaceous, nearly straight, less than 2 cm. long, 4 mm. thick, long-acuminate, minutely strigose, half 2-celled.

This is related to *A. Lambertii* and *A. sericeus*. From the former it differs in the shorter and broader leaflets and the more spreading leaves; from the latter in being greener, less hairy, and having narrower bracts and calyx-tube and darker flowers, and from both in the smaller size, thinner and more spreading legumes and smaller flowers.

COLORADO: Plains and foothills near Boulder, 1902, *F. Tweedy 5164* (type); between Sunshine and Ward, *no. 5165;* Eldora to

Baltimore, *no. 5634;* Sargents 1901, *C. F. Baker 344;* Cimarron, *no. 277.*

WYOMING: Laramie Plains, 1903, *Goodding 1422;* Centennial, 1900, *Aven Nelson 7680.*

NEBRASKA: Hay Springs, 1901, *MacDougal 44.*

Aragallus angustatus sp. nov.

Acaulescent perennial; leaves spreading or ascending, 6–10 cm. long; leaflets 7–13, narrowly linear-lanceolate to narrowly linear, 1–2 cm. long, 2–4 mm. wide, sparingly strigose; scape about 1 dm. high, sparingly strigose; raceme 3–5 cm. long; bracts lanceolate, about 5 mm. long; calyx finely silky-strigose; tube 5–6 mm. long; teeth subulate, about 2 mm. long; corolla purple, 15 mm. long or less; banner rather broad; wings broad and slightly emarginate; keel with a very dark blue-purple spot and a very short porrect tip; legume ovoid, less than 1.5 cm. long, coriaceous, 3.5 mm. thick, rather abruptly contracted into a spreading beak, minutely strigose, half 2-celled.

This resembles, somewhat, a low, narrow-leaved *A. Lambertii*, but differs in the more spreading leaves, and smaller, more spreading flowers, and especially by the short pod, with an abrupt spreading beak. The specimen designated as the type has the best developed fruit.

NEBRASKA: Hills, Rush Creek, 1891, *Rydberg 82c* (fruit, type in herb. Columbia Univ.); prairies, Banner Co., *no. 82a*, in part (fruit); hills, Banner Co., *no. 82b* (flowers); Hay Springs, 1901, *MacDougal 64b* (flowers).

ARAGALLUS BLANKINSHIPII A. Nelson

Prof. J. W. Blankinship * writes:

"*Oxytropis Besseyi* (Rydberg); *Aragallus Besseyi* Rydberg, Flora 250 is *A. Blankinshipii* Nelson, Erythea, 7: 58. The types of both were collected within a few miles of each other. The fruiting specimens of Nelson were pathogenic, infected with uredo, causing the ovary to remain undeveloped and an abnormal calyx, the legume in the species usually exceeding the calyx; otherwise they are identical."

This statement is only partly correct. Professor Blankinship some time ago sent us specimens of *Aragallus Blankinshipii* from the type collection. The flowering specimen is identical with my *A. Besseyi*, but the fruiting specimen is not. The flowering specimen has long linear-subulate calyx lobes, 4 mm. long, and linear-lanceolate, acute bracts, while in the fruiting specimen the calyx-lobes are almost triangular and about half as long and the bracts lance-oblong and obtuse. If the fruit of the type sheet is infected by uredo, there is no evidence of it in the duplicate here at the Botanical Garden. The trouble is that *Aragallus Blankinshipii* was described from flowering specimens of one species (*A. Besseyi*) and fruiting specimens of another. They are both well known to me. I intended to describe the second species in the Flora of Montana when in the meantime Professor Nelson's article in Erythea appeared. I had no authentic specimens of his new species. As I knew of no species answering to Professor Nelson's description of *A. Blankinshipii*, never suspecting it to be a composite one, and knowing one agreeing fairly with his description of *A. collinus* except as to the color of the corolla, I referred the specimens of my supposed new species to this. The New York Botanical Garden has since received authentic specimens of both *A. Blankinshipii* and *A. collinus* and I have been able to correct my mistake. The specimens referred to *A. collinus* in my Flora of Montana are specifically the same as the fruiting specimens of *A. Blankinshipii.* Mr. Gooding has also collected good fruiting specimens in Wyoming at Alcona, Natrona County, in 1901 (*no. 147*). These were determined as *A. Blankinshipii.*

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* Mont. Agr. College Sci. Stud. Bot. 1: 80. 1905.

This species is closely related to *A. nanus*, differing mostly in the erect stiff scape and more elongated spike. *A. Besseyi*, together with *A. argophyllus*, forms a small group more related to *A. Lambertii.*

I adopt the name *A. Blankinshipii* for this species, represented by the fruiting specimens of the original description for the following reasons: (1) Prof. Nelson has laid most stress on the structure of the pod, associating *A. Blankinshipii* with *A. collinus*, *A. multiceps*, *A. Lagopus* and *A. nanus*, to which this species is related; (2) The characters of the fruit in the genus *Aragallus* are more reliable then those of the flowers to show the actual relationship; (3) The species represented by the flowering specimens has already received a name. The synonymy of the two species is as follows:

ARAGALLUS BLANKINSHIPII A. Nelson Erythea 7: 58 (fruiting specimens). 1899.

Aragallus collinus Rydb. Mem. N. Y. Bot. Garden. 1: 254. 1900. Not *A. collinus* A. Nelson 1899.

ARAGALLUS BESSEYI Rydb. Mem. N. Y. Bot. Garden 1: 250. 1900.

Oxytropis argentata Pursh Fl. Am. Sept. 473. 1814. Not. *O. argentata* Persoon.

Aragallus Blankinshipii A. Nelson. Erythea, 7: 58 (flowering specimens). 1899.

Aragallus monticolus A. Nelson, Erythea 7: 62, in part. 1899. Not *Oxytropis monticola* A. Gray.

Oxytropis Besseyi Blankinship, Mont. Agr. Coll. Sci. Stud. Bot. 1: 80. 1905.

Aragallus atropurpureus sp. nov.

Acaulescent perennial; leaves numerous, 3–7 dm. long; leaflets oval to oblong, canescently silky-villous, 5–15 mm. long, 3–5 mm. wide, obtuse or acute; scape 6–10 cm. long, loosely villous; raceme short and headlike; 2–3 cm. long; bracts linear-subulate, 5–10 mm. long; calyx dark, villous with mixed black and white hairs; tube 5 mm. long, 3 mm. wide; teeth black-hairy, subulate, 4 mm. long; coralla dark-purple, about 15 mm. long; wings deeply emarginate; keel with a rather long ascending tip; legume ovoid, less than 1.5 cm. long, 15 mm. thick, abruptly acuminate with a spreading beak, villous, partly black-hairy, thin, half 2-celled.

In pubescence and leaf-form, this species most resembles *A. sericeus*, but it is a much smaller plant, has only half 2-celled, shorter and more curved pod. It is easily distinguished from all the other purple-flowered species of the *A. Lambertii* group by the black-hairy calyx and long calyx-teeth.

WYOMING: Headwaters of Tongue River, Big Horn Mountains, 1898, *F. Tweedy 125* (type, in flower); *no. 126* (in fruit).

Hedysarum utahense sp. nov.

Perennial with a rootstock; stem 4–6 dm. high, finely strigose, stipules triangular, acuminate, 5–8 mm. long; leaves –15 cm. long; leaflets 11–17, elliptic, oval or oblong, usually rounded at both ends, 1–3 cm. long, 5–10 mm. wide, glabrous above, finely cinereous-strigose or more glabrate beneath; peduncles about 1 dm. long; raceme 4–10 cm. or in fruit even 2 dm. long; bracts ovate to lanceolate, scarious; calyx cinereous-strigose; tube nearly 3 mm. long; teeth lance-subulate, 5 mm. long, attenuate; corolla rose-purple; banner 15–18 mm. long; keel 18–20 mm.; loments minutely strigose; internodes 2–5, 6–8 mm. long, 5–6 mm. wide; nodes narrow, 2.5 mm. or less.

This is related to the subarctic *H. Mackenzii*, from which it differs in the denser pubescence on its calyx, its broader calyx-teeth, its fewer and larger internodes of the loment, its taller habit, broader bracts and lighter and redder flowers. It grows on hillsides at an altitude of 1400–2000 m.

UTAH: Vicinity of Salt Lake City, 1883, *Leonard 55* (type); 1900, *Stokes;* 1869, *Watson 294;* near Ogden, *Coulter; Stansbury;* Wahsatch Mountains, 1888, *Dr. Eccles.*

Lathyrus brachycalyx sp. nov.

Perennial with a creeping rootstock; stem simple or slightly branched, 1.5–3 dm. high, usually finely pubescent, sharply 4-angled; stipules semi-sagittate, 5–10 mm. long, 1.5–3 mm. wide, pubescent; rachis 2–5 cm. long, somewhat winged; leaflets 2–5 pairs, linear-oblong or oblanceolate, firm, strongly veined, finely pubescent, acute at both ends, 1–3 cm. long, 2–8 mm. wide; tendrils of the lower leaves reduced to mere tips, those of the upper leaves better developed, but usually simple; peduncles 5–10 cm. long; raceme short, 2–6-flowered; calyx puberulent; tube 4–5 mm. long; upper teeth broadly triangular, scarcely 2 mm. long, the rest lance-subulate, the lowest one 3 mm., rarely 4 mm. long; corolla purple, 2–2.5 cm. long; legume glabrous, 3–4 cm. long, 7 mm. wide.

This species has been confused with *L. decapetalus* and is closely related to it. It differs in the much shorter calyx-tube and calyx-teeth, the broader, more upturned banner, the more pubescent foliage and less well developed tendrils. It grows on hillsides and in cañons and washes at an altitude of 1400–2500 m.

UTAH: City Creek Cañon, 1883, *F. E. Leonard 101* (type), *20* and *29;* 1900, *S. G. Stokes;* 1880, *M. E. Jones 1700;* near Salt Lake City, 1904, *Garrett 998;* 1905, *Rydberg 6162;* Mt. Majestic, *Garrett 1656;* Mount Nebo, 1902, *Goodding 1105;* Wahsatch Mountains, 1869, *S. Watson 295.*

Capnoides hastatum sp. nov.

Glabrous green perennial, 1–1.5 m. high, branched above; leaves 2–4 dm. long, thrice pinnatifid; ultimate divisions elliptic or oval, 1–2 cm. long, mucronate; racemes 1 dm. long or more; bracts oblanceolate, about 1 cm. long; pedicels about 3 mm. long; sepals narrowly hastate with broad often toothed, divergent basal lobes, about 2 mm. long; corolla with the spur 15–18 mm. long, salmon-pink; hood scarcely crested.

This species is closely related to *C. Cusickii* (S. Wats.) Heller, but differs in the smaller corolla, less crested hood and the sepals which are hastate instead of reniform and laciniate.

IDAHO: Lolo Creek, 1902, *C. V. Piper 4057* (type in herb. N. Y. Bot. Garden).

Capnoides brachycarpum sp. nov.

Glabrous and glaucous perennial with thick root; stem 3–6 dm. high, branched above; leaves 2–3 dm. long, thrice pinnatifid; ultimate divisions lanceolate or lance-elliptic, 2–3 cm. long, 5–12 mm. wide; racemes 1–2 dm. long, the upper often branched; bracts linear-subulate, about 5 mm. long; pedicels ascending, about 5 mm. long; sepals ovate, acute, 2–3 mm. long with toothed auricles at the base; corolla, including the spur, about 15 mm. long, yellowish, the inner petals tipped with purple or brown; spur about the length of the body of the petals, horizontal; crest of the hood obsolete; pod horizontal or reflexed, obovoid, about 1 cm. long and 6 mm. wide.

This species was included in the original description of *Corydalis Brandegei* S. Wats., but the type of the latter and all Colorado specimens can easily be distinguished by the green, scarcely glaucous foliage, the broader oval or obovate mucronate divisions of the leaves, the broader and obtuse sepals, the longer corolla, which is fully 2 cm. long and has an almost erect spur, and the fruit, which is fully 1.5 cm. long but scarcely more than 4 mm. thick. *C. brachycarpum* grows along streams at an altitude of nearly 3000 m.

UTAH: Alta, 1879, *M. E. Jones 1197* (type in herb. N. Y. Bot. Gard.); 1905, *Rydberg 6848;* Silver Lake, American Fork Cañon, 1895, *M. E. Jones;* Wahsatch Mountains, 1884, *Leonard 175*.

Lepidium Crandallii sp. nov.

L. Jonesii Rydb. Bull. Ag. Ex. Sta. Colo. **100**: 152, in part. 1906.
L. Eastwoodiae Rydb. *l. c.* in part.

Perennial; stems several, branched and leafy throughout, glabrous or puberulent above, 3–5 dm. high; basal leaves and lower stem-leaves pinnatifid, 5–7 cm. long, glabrous, with oblanceolate or oblong, entire or slightly toothed divisions; upper stem-leaves, especially those of the branches, oblanceolate or linear, entire or toothed; sepals oblong, nearly 2 mm. long, white-margined; petals clawed, about 3 mm. long, white, their blades obovate; stamens 6; fruiting racemes 5–10 cm. long; pedicels divergent; pods oval or ovate, about 4 mm. long, glabrous, slightly wing-margined above; style 1 mm. long, about twice as long as the wing-margin.

This species is related to the two species to which it has been referred and to *L. allyssoides*. From the latter and *L. Eastwoodiae* it differs in the more commonly dissected stem-leaves, the broader and shorter segments of the leaves and the comparatively longer style. From *L. Jonesii* it differs in the broader leaf-segments, thinner leaves, and more branched habit. From *L. scopulorum* it differs in the less woody base, the branched and leafy stem, thinner leaves and shorter styles.

COLORADO: Palisades, May 14, 1898, *Crandall 131* (type in herb. N. Y. Bot. Gard.); Glenwood Springs, 1902, *Osterhout 2599*;

Lepidium brachybotryum sp. nov.

Biennial or perennial with a tap-root; stem 2–3 dm. high, branched, puberulent throughout; basal leaves puberulent, bipinnatifid, about 5 cm. long, with elliptic or obovate lobes; stem-leaves oblanceolate, pinnatifid or toothed; sepals oblong, about 1 mm. long, white-margined; petals white, clawed, 2 mm. long, their blades broadly obovate; stamens 6; fruiting racemes short, 2–5 cm. long; pedicels divergent, 5–7 mm. long; pod rounded-ovate, 3 mm. long, 2.5 mm. wide, wing-margined above; styles less than 0.5 mm. long, scarcely exceeding the wing-margins.

This is related to *L. montanum* but differs in the short style, more rounded pods, and short racemes. It grows on sage-brush flats.

UTAH: Juab, 1902, *Goodding 1075* (type in herb. N. Y. Bot. Gard.); Wasatch County, near Midway, *Carlton & Garrett 6728* (poor specimen doubtfully referred here).

Lepidium Fletcheri sp. nov.

Annual or biennial; stem erect, 3–5 dm. high, puberulent with short cylindric spreading hairs, branched above with ascending branches; leaves narrow, pinnatifid with linear divisions or saliently toothed, 2–5 cm. long, puberulent; those of the inflorescence linear and entire; sepals oblong, scarcely 1 mm. long, green, with white margins; petals none; stamens usually 2, scarcely exceeding the sepals; fruiting racemes 3–5 cm. long; pedicels 4 mm., terete; pod glabrous, scarcely 3 mm. long, obovate in outline, glabrous, strongly wing-margined above; lobes of the wings nearly 0.5 mm., triangular-ovate, acutish or obtuse; seed 1 mm. long, brown, wingless.

This species is related to *L. densiflorum* and *L. ruderale*, but differs from both in the deeper, more open notch of the pod and the prominent lobes of the wing. From the former it differs also in the smaller pod and the narrow divisions of the leaves and from the latter in the leaves, of which none, apparently, are bipinnatifid. In the fruit it resembles *L. Bourgeauanum* Thelling, but differs in the simple erect habit and in the pinnatifid leaves.

MANITOBA: Roadsides, Winnipeg, 1905, *J. Fletcher* (type in herb. N. Y. Bot. Gard.); apparently also

SASKATCHEWAN: Cherryfield, 1906, *Macoun & Herriot 69881.*

THELYPODIUM Endl.

This genus as treated in the Synoptical Flora represents at least half a dozen different types of plants. Whether they should be regarded as one or more genera depends upon the individual tastes and inclinations of the botanist treating them. Dr. Greene, in splitting up the genus *Streptanthus*, expressed the opinion that either these two genera, *Stanfordia* and *Caulanthus*, should be united into one, or else *Streptanthus* should be divided into several. The writer agrees so far with Dr. Greene and thinks that *Thelypodium* and *Caulanthus* should be treated the same way. He has not been able to follow Dr. Greene in his segregation, however, partly because he does not know well enough the West American species treated by Dr. Greene, and partly because his opinions differ considerably in some cases. One of these cases will be given below.

Thelypodium was established by Endlicher, and based wholly on *Pachypodium* Nutt.* A generic diagnosis was given but no species were cited. In Walpers' Repertorium (1 : 172), the genus was again taken up and the three species of *Pachypodium* found in Torrey and Gray's Flora, were taken up in the same order as these. Hence *Thelypodium* is a mere substitute for *Pachypodium*, which name had been used for another genus, and the type of the latter genus is the type of the former. The three species of *Pachypodium* are the following, given in the order in which they appear: *P. laciniatum*, *P. integrifolium*, *P. sagittatum*. The last of the three need not be considered, for in Torrey and Gray's Flora it is regarded as doubtfully belonging to the same genus as the preceding and perhaps belonging to a section of *Arabis*. The type of *Pachypodium* Nutt., and hence of *Thelypodium* Endl., must then be either *P. laciniatum* or *P. integrifolium*. There is nothing that points directly to either of the two, but everything favors the former. It is not only the first species mentioned, but it is also the only one previously known and figured. It was first described as *Macropodium laciniatum*. Hooker compared it with the original *M. nivale*, gave figures for both and emphasized the differences between the two, the oblong anthers and the long, slender pubescent stipe of *M. nivale* and the linear anthers and the short, stout stipe of *M. laciniatum*. Nuttall remarked "evidently not a *Macropodium*." It is evident that he selected the name *Pachypodium* from the short, stout stipe.

If *Macropodium laciniatum* Hook. is regarded as the type of *Thelypodium* Endlicher, and the writer can not regard it otherwise, the closest relatives of it we find in *T. utahense* Rydb. and the groups of *Thelypodia* on which Dr. Greene based his genus *Guillenia*. It is hard to see how *Thelypodium lasiophyllum* Greene, the type of the latter genus, can be generically distinct from *T. laciniatum* (Hook.) Endl. Every character pointed out by Dr. Greene for his *Guillenia* agrees with the latter and is even found in Hooker's description. It will be admitted that there are some habitual differences, by which *T. laciniatum* is isolated from *Guillenia*, but *T. utahense*, originally named *T. laciniatum*, has the habit of that genus, while the flower and fruit are essentially those of *T. lasiophyllum*.

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* T. & G. Fl. N. Am. 1 : 96. 1838.

Dr. Greene evidently intended to include in *Guillenia*, *Arabis longirostris* or *Streptanthus longirostris*, but in enumerating the species of his new genus he has no *G. longirostris*. He has one *G. rostrata* based on *Arabis rostrata* S. Wats., a name the publication of which I have been unable to find. *Arabis longirostris* is hardly congeneric with *Telypodium lasiophyllum*, however. It has the flat pod of *Streptanthus*, but the short anthers, merely cordate at the base, and not spirally curved, place it as very doubtfully belonging to any of the Streptanthoid genera.

The second species of *Pachypodium* in Torrey and Gray's Flora, now usually known as *Thelypodium integrifolium* (Nutt) Endl., is so different in habit, that the writer has always found it hard to regard it as congeneric with the rest, but the differences in the structure of the flower and of the pod externally are so slight that a segregation based on habit alone would not be desirable. There is however, a character in the pod, unique to this species and two or three segregates from it and making them stand isolated from all the other Thelypodioid plants, viz., the strong and broad midrib of the septum of the pod. There is no distinct midvein in any of the typical *Thelypodia*.

A species closely resembling *T. integrifolium* in habit, foliage and flowers, is *T. linearifolium* or *Iodanthus* or *Streptanthus linearifolius*, but it lacks the rib on the septum. Besides it has two characters not found in the other *Thelypodia*. Two of the rather firm and purple sepals are strongly saccate at the base and the stigma is conical, not truncate nor 2-lobed as in the other species. It could be referred to *Hesperis*, which it resembles especially in the flowers, if it were not for the stipitate, terete pod and the curved anthers, which characters are strongly thelypodioid.

In describing the subgenus *Euthelypodium* in the Synoptical Flora, Dr. Robinson gives *T. elegans* Jones as an exception having a 2-lobed stigma with the lobes expanding over the septum. In the whole tribe the stigma is either undivided or else the lobes are expanded over the valves. This exceptional character is most pronounced in the species mentioned above, but it is also found in less degree in *T. aureum* Eastw. and *T. Bakeri* Greene. Mr. George Osterhout, of New Windsor, Colorado, who has collected a specimen of *T. elegans*, has written on the label: "near to

Streptanthus wyomingensis A. Nelson but probably rather a *Thelypodium.*" This note made the writer compare the latter species. When *S. wyomingensis* was first described, it was thought that it was the closest relative of *S. maculatus* Nutt., the only original *Streptanthus,* but a closer comparison now has shown that the pod is not flat as in *Streptanthus* and the lobes of the stigma are turned the wrong way. Its relationship is with the three *Thelypodia* just mentioned above, with which it also agrees in habit.

Two other species of *Thelypodium* are said by Dr. Robinson to have the lobes of the stigma placed in the same way, viz. : *T. micranthum* and *T. longifolium,* but here that character is scarcely noticeable. There are other characters in which they disagree with the other *Thelypodia.* The branched or stellate pubescence is unique in the whole tribe and should place them according to the classification used in Engler & Prantl's Pflanzenfamilien in another grand division of the family. The stamens and the pods are, however, more or less thelypodioid. In both species the flowers are more or less irregular, the lower sepals being longer (this is best shown in *T. longifolium*) and there is scarcely any distinction between claw and blade in the petals.

The most interesting of the *Thelypodia* is perhaps *T. Wrightii.* In the pod, the texture of sepals and petals, the form of the latter, etc., this is close to the typical *Thelypodia.* The habit is not so essentially different either, but the sepals are spreading-reflexed and early deciduous as in *Stanleya* and the glands at the base of the stamens and the thickening of the pedicel, both so conspicuous in most thelypodioid plants, are here inconspicuous. The plant could not be included in *Stanleya,* on account of the short stipe, the different habit and the structure of the petals.

The genera may be distinguished as follows :

- Sepals equal or nearly so ; hairs simple or none.
  - Sepals erect or ascending in anthesis.
    - Stigma distinctly lobed, its lobes expanded over the septum. *Thelypodiopsis.*
    - Stigma entire or, if indistinctly lobed, the lobes expanded over the valves.
      - Stigma truncate ; sepals scarcely gibbous at the base.
        - Septum of the pod without a distinct midrib. *Thelypodium.*
        - Septum of the pod with a strong midrib. *Pleurophragma.*
      - Stigma conical ; the outer sepals gibbous at the base. *Hesperidanthus.*
  - Sepals strongly spreading or reflexed in anthesis, soon deciduous. *Stanleyella.*

Sepals unequal, the lower longer; hairs, at least some of them, stellate or branched, *Heterothrix.*

THELYPODIOPSIS gen. nov.

Biennials with rather thick and glaucous foliage and glabrous except the lower part of the stem. Basal leaves spatulate or oblanceolate, more or less toothed, with winged petioles; stem-leaves auriculate-clasping with rounded auricles. Sepals thin, erect or ascending, not gibbous, more or less petaloid, linear or oblong. Petals more or less clawed, white or purplish or in one species yellow. Filaments distinct, slender, filiform or subulate; anthers long, linear, sagittate at the base, soon spirally curved. Pod slender, terete, more or less torulose, usually with short stipe and style; stigma 2-lobed, the lobes expanded over the septum; cotyledons obliquely incumbent.

The first species of this genus as well as of the following new genera is regarded as the type.

Stipe very short, less than 1 mm. long or almost none; petals white or tinged with purple.
Style 2 mm. or nearly so.
Pod 7–9 cm. long. *T. elegans.*
Pod about 4 cm. long. *T. Bakeri.*
Style less than 1 mm. long; pod 5–7 cm. long. *T. wyomingensis.*
Stipe 2–5 mm. long; petals and sepals yellow. *T. aurea.*

Thelypodiopsis elegans (M. E. Jones).

Thelypodium elegans M. E. Jones, Zoe **4**: 265. 1893.

Thelypodiopsis Bakeri (Greene).

Thelypodium Bakeri Greene, Pl. Baker. **3**: 8. 1901.

Thelypodiopsis wyomingensis (A. Nelson).

Streptanthus wyomingensis A. Nelson, Bull. Torrey Club **26**: 126. 1899.

Thelypodiopsis aurea (Eastw.).

Thelypodium aureum Eastw. Zoe **2**: 227. 1891.

Thelypodium Palmeri sp. nov.

Biennial or perennial with a tap-root; stem 3–5 dm. high, sparingly hirsute below, glabrous above; basal leaves oblanceolate or spatulate, 2–4 cm. long, more or less hirsute beneath, especially on the veins; stem-leaves sagittate, 2–4 cm. long, glabrous or nearly so; inflorescence usually branched with ascending branches; pedicels nearly erect, 5–8 mm. long; sepals oblong, 3–4 mm. long; petals 5–6 mm. long, white or rose; claw about 3 mm. long; blade spatulate or oblanceolate; pod about 2–5 cm. long, 1 mm. wide.

This species has been confused with *T. sagittatum* (Nutt.) Endl., but differs in the smaller and narrower petals, nearly erect pedicels and narrow pod.

SOUTHERN UTAH: 1877, *E. Palmer 25* (type in herb. Columbia Univ.).

Thelypodium leptosepalum sp. nov.

Annual or biennial, glabrous throughout; stem 4–6 dm. high, branched; leaves thin, glabrous, 6–10 cm. long, lyrate-pinnatifid with lanceolate divergent lobes; flowering pedicels about 3 mm. long; sepals lance-subulate, 6 mm. long, 1–1.5 mm. wide at the base, white; petals narrowly linear-oblanceolate, almost strap-shaped, with scarcely any distinction between blade and claw, 8 mm. long, 0.5 mm. wide or less; filaments filiform, about 1 cm. long when well developed; anthers linear, sagittate at the base, soon curled.

This is closely related to *T. laciniatum* (Hook.) Endl., but differs in the narrow tapering instead of oblong sepals. It grows at an altitude of 450–600 m. on rocky banks.

IDAHO: Lewiston, Nez Perces County, 1896, *A. A. & E. Gertrude Heller 3022* (type in herb. Columbia Univ.); Valley of Peter Creek, Nez Perces County, 1892, *Sandberg, MacDougal & Heller 122.*

PLEUROPHRAGMA gen. nov.

Tall glabrous perennials or biennials with paniculate inflorescence and thick entire leaves. Basal leaves oblanceolate or spatulate; stem-leaves linear-lanceolate, sessile but not clasping. Sepals ascending, thin, more or less petaloid. Petals white or purplish with slender claws. Filaments distinct, subulate, white, somewhat dilated below and with conspicuous glands at their bases; anthers linear, sagittate at the base, curved. Receptacle dilated. Pod slender, terete, torulose, tapering at both ends into a short stipe below and a short slender style above; stigma minute, entire; septum with a strong midrib.

Pleurophragma integrifolium (Nutt.)

Pachypodium integrifolium Nutt.; T. & G. Fl. N. Am. **1**: 96. 1838.

Thelypodium integrifolium Endl.; Walp. Rep. **1**: 172. 1842.

Pleurophragma gracilipes (Robinson)

Thelypodium integrifolium gracilipes Robinson, Syn. Fl. **1**^{1} 176. 1895.

Pleurophragma platypodum sp. nov.

Glabrous perennial with a tap-root; stem simple up to the inflorescence, 1–2 m. high; basal leaves spatulate, 5–10 cm. long, entire; stem-leaves 3–6 cm. long, linear-lanceolate or oblanceolate, dark-green, thick; inflorescence paniculate; racemes dense, at first corymbiform, in fruit about 1 dm. long; sepals oblong, yellowish- or greenish-white, 4 mm. long; petals white, clawed, 6–7 mm. long; blades spatulate; pedicels in fruit about 3 mm. long, divergent or somewhat reflexed, dilated and flattened at the base, pod 1.5–2 cm. long, 1–1.5 mm. thick, torulose; stipe 1–2 mm. long; style short.

This is related to *Pleurophragma integrifolium* (*Thelypodium integrifolium* Endl.), but differs in the shorter inflorescence, the shorter pedicels, broadened at the base, the shorter pod with longer stipe and shorter style.

UTAH: Moab, 1891, *M. E. Jones* (labeled *Thelypodium Wrightii*, type in herb. N. Y. Bot. Garden).

ARIZONA: 1876, *E. Palmer.*

To this genus belongs also *Thelypodium lilacinum* Greene, Pl. Baker. 3: 9. 1901, if distinct from *T. integrifolium.* The only specimens at hand differ from that only in the stronger purple color of calyx and corolla. They are without fruit, which, however, may furnish distinctive characters.

HESPERIDANTHUS (B. L. Robinson) Rydb., gen. nov.

Thelypodium § *Hesperidanthus* B. L. Robinson, Syn. Fl. 1^1: 174. 1895.

Erect, slender, glabrous perennials, with pale foliage; corymbosely branched above. Basal leaves obovate, toothed; stem-leaves linear, entire. Sepals rather firm, erect; the outer strongly saccate at the base. Petàls purple, with obovate blades. Anthers linear, sagittate at the base, strongly curved. Stigma conical or ovate, neither truncate nor 2-lobed. Pod terete, linear, short-stipitate.

Hesperidanthus linearifolius (A. Gray).

Streptanthus linearifolius A. Gray, Pl. Fendl. 7. 1849.

Iodanthus or *Pachypodium linearifolium* A. Gray, Proc. Am. Acad. 6: 187. 1863.

Thelypodium linearifolium S. Wats. Bot. King's Expl. 25. 1871.

STANLEYELLA gen. nov.

Tall branched biennials. Leaves thin, the lower ones lyrately pinnatifid, the upper entire. Sepals thin, petaloid, white, oblong or linear, spreading or even reflexed in anthesis. Petals white, with oblanceolate or spatulate blades gradually tapering into a short claw. Filaments distinct, filiform; anthers linear, sagittate at the base, soon more or less spirally recurved. Pod slender, terete with short stipe and short style; stigma small, truncate or nearly so; cotyledons incumbent and somewhat conduplicate.

Stanleyella Wrightii (A. Gray)

Thelypodium Wrightii A. Gray. Pl. Wright. **1**: 7. 1852.

HETEROTHRIX (B. L. Robinson) Rydb., gen. nov.

Thelypodium § *Heterothrix* B. L. Robinson, Syn. Fl. $\mathbf{1}^1$: 178. 1895.

Slender biennials, more or less pubescent at least below with stellate or branched hairs. Basal leaves oblanceolate, more or less toothed; stem-leaves lance-linear or linear, entire. Racemes elongated, slender. Calyx more or less oblique, the lower sepals being longer than the upper, all ascending, rather firm and more or less purplish. Petals oblanceolate or spatulate, indistinctly or broadly clawed. Filaments subulate, broad at the base, distinct, scarcely exserted; anthers linear, sagittate at the base, spirally curved. Pod slender, terete, sessile; stigma minute, entire or slightly lobed, the lobes expanding over the septum; cotyledons obliquely incumbent.

Heterothrix longifolia (Benth.)

Streptanthus longifolius Benth. Pl. Hartw. 10. 1839.
Thelypodium longifolium S. Wats. Bot. King's Expl. 25. 1871.

Heterothrix micrantha (A. Gray)

Streptanthus micranthus A. Gray Pl. Fendl. 7. 1849.
Thelypodium micranthum S. Wats. Proc. Am. Acad. **17**: 321. 1882.

CHLOROCRAMBE gen. nov.

Perennial glabrous herbs; stem simple at least up to the inflorescence. Racemes lax with slender horizontal or reflexed pedicels. Leaves thin, petioled, with usually hastate blades. Sepals greenish, ascending. Petals greenish-white, with short claws and lanceolate dentate blades. Anthers sagittate at the base, linear-oblong, at last curved, greenish. Pod slender, somewhat torulose, short-stipitate and short-styled; stigma minute, entire.

The plant referred here has been included in *Caulanthus*, but the type of that genus, *C. crassicaulis*, and its allies have an urn-shaped, more or less closed calyx; linear, oblong, or spatulate petals, which have practically no claws, are thin and membranous except the upper third or fourth, which is thicker, brownish or purplish, curved and crisp; and a conspicuous, two-cleft stigma.

Chlorocrambe hastata (S. Wats.) Rydb.

Caulanthus hastatus S. Wats. Bot. King's Expl. 28. 1871.

Sophia magna sp. nov.

Annual; stem branched, 5–10 dm. high, sparingly stellate-puberulent or glabrous, stout; basal leaves twice to thrice pinnatifid, 1–2 dm. long, nearly glabrous; segments obovate, often toothed; stem-leaves similar but with narrower segments; sepals yellow, 2 mm. long, oblong; petals spatulate, nearly 3 mm. long, rather light-yellow; pedicels in fruit 15–20 mm. long, ascending; pod glabrous, more or less clavate, 12–15 mm. long, 1.5–2 mm. thick; seeds more or less in two rows.

This species is related to *S. intermedia* and *S filipes*, but differs from both in the broad segments of the basal leaves. In habit it therefore resembles *S. incisa*, but has an evidently clavate pod. It has the conspicuous flowers of *S. filipes*, but the terminal segment of the leaves is not elongated. It was first mistaken for *S. brachycarpa*; but the style is evident although short. It grown on river-bluffs at an attitude of 1500–2500 m.

COLORADO: North of La Veta, 1900, *Rydberg & Vreeland 6163* (type in herb. N. Y. Bot. Gard.); South of La Veta, *6162*; Plains near Denver, *6164*.

Sophia Nelsonii sp. nov.

Slender annual; stems 2–4 dm. high, slightly stellate or glabrate; leaves pinnatifid or bipinnatifid with linear or oblong divisions, slightly stellate or glabrate; sepals oblong, 1 mm. long; petals light-yellow, spatulate, 1.5 mm. long; fruiting pedicels ascending, 4–6 mm. long; pods clavate, 5–8 mm. long, glabrous, slightly over 1 mm. thick; style minute.

This species is probably nearest related to *S. intermedia*, but differs in the shorter pod and pedicels and the smaller flowers. From *S. pinnata* it differs in being nearly glabrous and by the shorter pedicels and the erect pods. It grows on gravelly flats, sandy plains and rocky hills, at an attitude of 1300–2000 m.

WYOMING: Wraith Falls, Yellowstone Park, 1899, *Aven Nelson &Elias Nelson 5710* (type in herb. N. Y. Bot. Gard.); Green River. 1895, *Rydberg*; Fort Steele, 1901, *Tweedy 4479* and *4480* (?),

UTAH: Salt Lake City, 1884, *Leonard 212*.

Arabis oreophila sp. nov.

Arabis Drummondii alpina S. Wats. Bot. King's Expl. 17, in part. 1871.

Perennial with a more or less branched caudex; stems 1–2 dm. high; basal leaves numerous, broadly oblanceolate or spatulate, stellate-pubescent; stem-leaves rather few, lanceolate, slightly auriculate-clasping; sepals oblong, 3–4 mm. long, margined with purplish, obtuse, glabrous; petals 7–8 mm. long, yellowish-white below, upper portion rose or purplish; pedicels 4–10 mm. long, erect or ascending; pods glabrous, 3–6 cm. long, slightly arcuate, 2 mm. wide, acute, but beak obsolete; seeds in 2-rows, winged above and on one side.

This species is nearest related to *A. Lyallii* S. Wats., and was included therein, but differs in the broader and shorter basal leaves, which are decidedly stellate, and in the pod which lacks a distinct beak. It grows on the higher mountains at an altitude of 2500–3500 m.

UTAH: Divide between Big Cotton-wood Cañon and Heber Valley, 1905, *Rydberg & Carlton 6678* (type in herb. N. Y. Bot. Garden, flowers and young fruit); Alta, 1879, *Jones 1248* (fr.); Uintas, 1869, *Watson 75* (fl.)

WYOMING: Union Peak, 1894, *A. Nelson 1007* (fl.); upper Buffalo Fork, 1899, *C. C. Curtis*.

MONTANA: Old Hollowtop, 1897, *Rydberg & Bessey* (fl.).

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EDITED BY

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Director of Public Gardens and Plantations.

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THE SEDGES OF JAMAICA

BY

DR. N. L. BRITTON,

Director-in-Chief of the New York Botanical Gardens, &c.

PRICE—Threepence.

KINGSTON, JAMAICA:
HOPE GARDENS.

1907.

JAMAICA.

BULLETIN

OF THE

DEPARTMENT OF AGRICULTURE.

Vol. V. September, 1907. Supplement 1.

THE SEDGES OF JAMAICA.

BY N. L. BRITTON.

The list of species of Cyperaceae published herewith is based primarily on collections in the herbarium of the New York Botanical Garden, supplemented by those in the herbarium of the Department of Public Gardens and Plantations, and by notes taken at the herbaria of the Royal Gardens at Kew and at the British Museum of Natural History. The principal literature consulted has been the Monograph of the West Indian Cyperaceae by the late Mr. C. B. Clarke, published by Professor Urban in the second volume of his Symbolae Antillanae, Grisebach's Flora of the British West Indies, and the several papers of O. Boeckeler.

Most of the species may be regarded as satisfactorily known, and their general distribution ascertained, but a considerable number are, as will be seen in the enumeration, known only from single specimens secured by the older collectors, so that very much remains to be done in order to ascertain their relative abundance or rarity, their habitats and distribution; in some cases the only record that we have is that the specimen was collected somewhere on the island, and in a few instances it is suspected that errors have been made in the origin of the plant cited, through a mixture of labels in the older herbaria, or in some other way.

I have accepted the generic limits outlined by Mr. Clarke in the paper above cited with the exception of his treatment of *Cyperus* and its segregates, where I have accepted the view of previous authors in taking Cyperus in its broad sense rather than recognizing the genera *Pycraeus, Mariscus,* and *Torulinium,* as I believe the characters depended on by Mr. Clarke for the maintenance of these genera are too vague for satisfactory use. It is my opinion that either this course must be taken, or that *Eleocharis, Scirpus* and *Rynchospora* must also be split up in order to be consistent. On the other hand, I accept the genus *Abildgaardia* as distinct from *Fimbristylis,* though I am not altogether clear that this position is readily defensible. I have also diverged from Mr. Clarke's treatment in accepting the generic name *Stenophyllus,* for the plants he includes under *Bulbostylis,* the former name having evident priority and being based on a well-known type.

The paper is submitted as a contribution to knowledge of the Jamaica flora from the Tropical Laboratory of the New York Botanical Garden at Cinchona, which is held as a research station through the cordial co-operation of the Colonial Government. One of the great needs of this research station is a more accurate knowledge of the flora of the island for the use of students either in residence there or at other institutions, and it is hoped that such a descriptive flora may be prepared in co-operation with the botanists of the Government at no distant date. In order to accomplish this, however, a very large amount of additional exploration must be done; the co-operative arrangement now in progress is rapidly supplying much needed material through the collecting trips of Mr. William Harris, Superintendent of Hope Gardens, but his valuable time for this purpose is naturally limited and should be supplemented by the work of other collectors in order that the information necessary may be more rapidly obtained.

References to specimens and their collectors have been restricted for the most part to work of the last few years, the older specimens being comprehensively cited by Mr. C. B. Clarke in his monograph.

KEY TO THE GENERA OF JAMAICAN CYPERACEAE.

A. Fertile flowers perfect
  1. Basal empty scales of the spikelets none, or not more than two
    - Scales of the spikelets distichous
      - Spikelets with only one perfect flower 1. *Kyllinga*
      - Spikelets with 2 to many perfect flowers 2. *Cyperus*
    - Scales spirally imbricated (apparently distichous in *Abildgaardia*)
      - Base of the style persistent as a tubercle on the achene
        - Spikelet 1: bristles of the perianth usually present; culms leafless 3. *Eleocharis*
        - Spikelets several or numerous; bristles none; culms leaf-bearing 4. *Stenophyllus*
      - Base of the style not persistent as a tubercle
        - Flowers with no broad sepals nor perianth-scales
          - Base of the style swollen; perianth-bristles none
            - Scales of the nearly terete spikelets spirally imbricated 5. *Fimbristylis*
            - Scales of the distinctly flattened spikelet subdistichous 6. *Abildgaardia*
          - Base of the style not swollen; bristles usually present
            - Bristles 8 or fewer, short, rarely none 7. *Scirpus*
            - Bristles numerous, long-exserted 8. *Eriophorum*
        - Flowers with a perianth of 3 broad sepals 9. *Fuirena*

2. Basal empty scales of the spikelets 3 or more
Style 2-cleft, its base persistent as a tubercle on the achene
Bristles none; culm monocephalous — 10. *Dichromena*
Bristles usually present; culm usually polycephalous — 11. *Rynchospora*
Style 3-cleft, its base fused with the top of the achene — 12. *Cladium*
B. Flowers all imperfect; monoecious or dioecious sedges.
Pistillate flowers subtended by a scale; achene bony — 13. *Scleria*
Pistillate flowers enclosed by a perigynium (utricle)
A long hooked bristle protruding from the perigynium — 14. *Uncinia*
No hooked bristle — 15. *Carex*

1. KYLLINGA, Rottb. Descr. et Ic. 2. 1773.

Rootstock short or none; culms tufted
Fertile scale of the spikelet setulose on the keel — 1. *K. pumila*
Fertile scale of the spikelet smooth on the keel — 2. *K. odorata*
Rootstock elongated; culms not tufted
Leaf-blades short or elongated
Leaf-blades short, acute — 3. *K. pungens*
Leaf-blades long, attenuate — 4. *K. brevifolia*
Leaves reduced to sheaths — 5. *K. peruviana*

Type species, *Kyllinga monocephala*, Rottb.

1. KYLLINGA PUMILA, Michx. Fl. Bor. Amer. I: 28. 1803.

Roadside ditch, Stony Hill (Britton 832). Widely distributed in temperate and tropical America.

2. KYLLINGA ODORATA, Vahl, Enum. II: 382. 1806.
Kyllinga triceps, Griseb. Fl. Br. W. I. 568. 1866. Not Rottb. 1773.

In the lawns at Castleton Gardens (Britton 834); Temple Hall (Harris 9390). Previously collected in Jamaica by W. Wright. Widely distributed in warm and tropical America.

3. KYLLINGA PUNGENS, Link, Hort. Berol. I: 326. 1827.

Banks and along roads at higher elevations. Near Silver Hill Gap (Maxon 1124); Cinchona (Shreve; Harris 9501); Morce's Gap (Britton 217); Hardware Gap (Nichols 104). Not hitherto recorded from Jamaica.

4. KYLLINGA BREVIFOLIA, Rottb. Descr. et Ic. 13. 1773.
Kyllinga monocephala, Thunb. Fl. Jap. 35. 1784. Not Rottb. 1773.

In moist ground, common. Cinchona (Harris 9496, 9498). Marsh near Balaclava (Marble 704). Grisebach in Flora British West Indies attributes both *K. brevifolia*, Rottb. and *K. monocephala*. Rottb. to Jamaica but the latter is purely an Old World species,

5. KYLLINGA PERUVIANA, Lam. Encyc. III: 366. 1789.
Mariscus aphyllus, Vahl, Enum. II: 373. 1806.
Kyllinga aphylla, Kunth, Enum. II: 127. 1837.
Obtained in Jamaica by several collectors; not observed by us (J.P. 843).

2. CYPERUS L. Sp. Pl. 44. 1753.

Style-branches 2: achene lenticular	
Achene dorsally flattened	1. *C. laevigatus*
Achene laterally flattened	
Scales of the spikelets blunt, straw-colour	2. *C. densus*
Scales of the spikelets acute	
Scales 1.5 mm. long, dull; inflorescence compact	3. *C. odoratus*
Scales 2-2.5 mm. long, shining: inflorescence loose	4. *C. paniculatus*
Style-branches 3; achene turgid or trigonous	
A. Spikelets more or less flattened, not breaking up at the nodes	
1. Rachis of the spikelet persistent, the scales falling away from it	
a. Rachis-wings none, or very narrow	
Plants annual	
Scales sharply acuminate	5. *C. compressus*
Scales obtusish, often with purplish margins	6. *C. sphacelatus*
Plants perennial	
Spikelets only 1 or 2; culm and leaves filiform	7. *C. trichodes*
Spikelets several or numerous	
Spikelets spicate, about 1 mm. wide	8. *C. distans*
Spikelets digitate	
Stamens 3 or 2	
Scales acute or acuminate; basal leaves reduced to sheaths	9. *C. Haspan*
Scales mucronate or short-awned; basal leaves normal	
Leaves convolute, at least in drying	
Achene narrowly linear-oblong	10. *C. oxylepis*
Achene obovoid; culm viscid	11. *C. elegans*
Leaves flat, grass-like	12. *C. diffusus*
Stamen only 1.	
Spikelets lanceolate to oblong-lanceolate	13. *C. ochraceus*
Spikelets ovate, elongating in age.	

Leaves 5-6 mm. wide, transversely nerved between the veins 14. *C. vegetus*
Leaves 2-3 mm. wide, not transversely nerved between the veins 15. *C. surinamensis*

b. Rachis distinctly winged.
Plants perennial by rootstocks
Basal leaves grass-like; weed of waste and cultivated ground 16. *C.rotundus*
Basal leaves reduced to sheaths; tall marsh sedges with pseudo-septate culms
Culm terete 17. *C. articulatus*
Culm trigonous at the apex 18. *C. nodosus*
Annuals, flowering the first season
Basal leaves reduced to sheaths; involucral leaves very numerous, longer than the umbels 19. *C. giganteus*
Basal leaves normal, half as long as the culm or longer 20. *C. radiatus*

2. Rachis of the spikelet falling away above the two lower empty scales
Achene narrowly linear-oblong, 2.5 to 4 times as long as thick
Spikelets spicate, several-flowered 21. *C. platystachys*
Spikelets capitate or capitate-spicate, only 1-4—flowered.
Heads globose 22. *C. globulosus*
Heads cylindric 23. *C. cyperoides*
Achene obovoid or oblong, not more than twice as long as thick
Spikelets 1-5—flowered
Umbel simple, or culm monocephalous
Scales of the spikelets imbricated
Spikelets loosely spicate, tetragonous 24. *C. tetragonus*
Spikelets densely spicate or capitate
Spikelets 2-5 mm. long 25. *C. cayennensis*
Spikelets 1.5 mm. long or less
Spikes several, rarely solitary; leaves 2-3 mm. wide 26. *C. Swartzii*
Spike solitary, rarely 2; culms and leaves almost filiform 27. *C . granularis*

Scales of the spikelets distant; leaves 2 mm. wide or less; slender sedges
Spikelets 4-5 mm. long 28. *C. tenuis*
Spikelets 2 mm. long or less 29. *C. nanus*
Umbel compound
Spikes ovoid, 8-12 mm. thick 30. *C. Mutisii*
Spikes long-cylindric, 5-7 mm. thick 31. *C. ligularis*
Spikelets 15-25—flowered
Scales acute or mucronulate. awnless 32. *C. brunneus*
Scales awned, appressed 33. *C. confertus*
B. Spikelets nearly or quite terete, breaking up at the nodes into 1-fruited joints
Spikes solitary or 2; culm filiform; perennial by rootstocks 34. *C. filiformis*
Spikes umbellate; culms stout to slender; annuals, or at least without rootstocks.
Scales distant, not overlapping
Spikes loose; spikelets yellowish-brown 35. *C. ferax*
Spikes dense; spikelets red brown 36. *C. Vahlii*
Scales overlapping 37. *C. speciosus*
Type species, *Cyperus esculentus*, L.

1. CYPERUS LAEVIGATUS, L. Mant. 179. 1771.
Juncellus laevigatus, Clarke in Hook. f. Fl. Brit. Ind. VI: 596. 1893.
In marshes along the coast. Between Kingston and Spanish Town (Fawcett 8142); Rockfort (Britton 787; Harris 9564.) Widely distributed in warm and tropical regions both of the old world and the new.

2. CYPERUS DENSUS, Link, Jahrb. III: 83. 1820
Cyperus helvus, Liebm. Mex. Halvgr. 9. 1850.
Cyperus variegatus, Griseb. Fl. Br. W. I. 562. 1864. Not H. B. K.
Pycreus helvus, Clarke in Urban, Symb. Ant. II: 19. 1900.
Frequent in marshes and ditches. Temple Hall (Harris 9392); Port Antonio (Britton 872); Stony Hill (Britton 833). Tropical America.

3. CYPERUS ODORATUS, L. Sp. Pl. 46. 1753.
Cyperus polystachyus, R. Br. Prodr. 214. 1810.
Pycreus polystachyus, Beauv. Fl. d'Owar. II: 48. 1807.
Pycreus odoratus, Urban, Symb. Ant. II: 164. 1900.
In marshes near the coast, in the vicinity of Port Antonio (Marble 847; Britton 901). Not hitherto reported from Jamaica. Widely distributed in tropical regions.

4. CYPERUS PANICULATUS, Rottb. Descr. et Ic. 40. 1773.
Pycreus paniculatus, Nees, Linnaea, IX: 283. 1834.
Reported from Jamaica by Clarke, as collected by Purdie, under

the name *Pycreus polystachyus*, var. *laxiflora*, Ridley ; moist ground, Troy (Britton 663). Warm and tropical America.

5. CYPERUS COMPRESSUS, L. Sp. Pl. 46. 1753.
Jamaica (Sloane, pl. 76 f. 1, cited by Linnaeus ; Purdie). This common weed of nearly all warm and tropical countries does not appear to be abundant in Jamaica, as it is not represented in the herbarium of the Department of Public Gardens and Plantations.

6. CYPERUS SPHACELATUS, Rottb. Descr. et Ic. 26. 1773.
Jamaica, collected by several botanists as recorded by Grisebach and by Clarke (J. P. 853). Common in most parts of Tropical America.

7. CYPERUS TRICHODES, Griseb. Fl. Br. W.I. 564. 1864.
Marshes at lower elevations; apparently local. Near Balaclava (Marble 706.) Endemic.

8. CYPERUS DISTANS, L. f. Suppl. 103. 1781.
Frequent in wet or moist soil at middle elevations. Banks, Content Gap (Britton 39). Previously accredited to Jamaica by Swartz. Widely distributed in warm and tropical regions.

9. CYPERUS HASPAN, L. Sp. Pl. 45. 1753.
Marshes and wet meadows, collected by Alexander and by Wullschlaegel. Widely distributed in warm and tropical regions.

10. CYPERUS OXYLEPIS, Nees; Steud. Syn. Pl. Cyp. 25. 1855.
Collected in Jamaica by Alexander as recorded by Clarke. Northern South America.

11. CYPERUS ELEGANS, L. Sp. Pl. 45. 1753.
Cyperus viscosus, Sw. Prodr. 20. 1788.
Occasional in marshes at low elevations. Also on Cayman Brac (Millspaugh 1171). Common throughout the West Indies; Central America to Argentina.

12. CYPERUS DIFFUSUS, Vahl, Enum. II: 321. 1806.
Cyperus laxus, Griseb. Fl. Br. W. I. 563. 1864. Not Lam.
Frequent on moist banks and hillsides up to 500 m. Near Gordon Town (Britton 3); near Castleton (Underwood 113). Widely distributed in tropical regions, but not known from the northern West Indies.

13. CYPERUS OCHRACEUS, Vahl, Enum. II: 325. 1806.
Frequent in marshes and ditches at elevations up to 500 m. Port Antonio (Britton 858); near St. Paul, Cockpit Country (Marble 700): Mona Estate near Hope (Harris 8846; 8942). Widely distributed in Tropical America.

14. CYPERUS VEGETUS, Willd. Sp. Pl. I: 283. 1797.
Along a brook, Troy (Britton 460). Not otherwise known from the West Indies. Distribution: California to Chili.

15. CYPERUS SURINAMENSIS, Rottb. Descr. et Ic. 35. 1773.
This widely distributed Tropical American sedge is known to me from Jamaica only by a specimen collected by Hart, mixed with *C. ochraceus* , as recorded by Clarke.

16. CYPERUS ROTUNDUS, L. Sp. Pl. 45. 1753.
A weed in waste places and cultivated soil. Widely distributed in warm and tropical regions.

17. CYPERUS ARTICULATUS, L. Sp. Pl. 44. 1753.
Common in marshes at lower altitudes. Near Ferry River (Britton 392); Resource (Harris 6917). Widely distributed in tropical regions.

18. CYPERUS NODOSUS, Willd. Enum. Hort. Berol. 72. 1809. Recorded from Jamaica by Clarke, as collected by March. Distribution : Central America, Northern South America ; Martinique.

19. CYPERUS GIGANTEUS, Vahl, Enum. II : 364. 1806.
Cyperus elatus, Griseb. Fl. Br. W. I. 566, in part. 1866.
Coastal marshes and along lagoons. Ferry River (Fawcett & Harris ; Britton 396). West Indies and Central America to Uruguay.

20. CYPERUS RADIATUS, Vahl, Enum. II : 369. 1806. Shown in the Kew Herbarium by a specimen from Jamaica, according to Clarke, the collector not cited. Distribution : tropical regions of the Old World and the New.

21. CYPERUS PLATYSTACHYUS, Griseb. Fl. Br. W. I. 567. 1864.
Mariscus flabelliformis, H. B. K. Nov. Gen. & Sp. I : 215. 1815. Not *Cyperus flabelliformis*, Rottb.
Frequent on banks and along streams at low and middle elevations. Near Gordon Town (Britton 5) ; Troy (Britton 613) : near Port Antonio (Earle 625). Central America and northern South America : Martinique.

22. CYPERUS GLOBULOSUS, Aubl. Pl. Guiana, I : 47. 1775.
Mariscus echinatus, Ell. Bot. S. C. & Ga. I : 75. 1816.
Cyperus cyclostachyus, Griseb. Fl. Br. W. I. 567. 1864.
Mariscus globulosus, Urban, Symb. Ant. II : 165. 1900.
Jamaica, collected by March and by Hart. Distribution : Southeastern United States ; Bermuda ; Porto Rico (according to Clarke) ; Guiana.

23. CYPERUS CYPEROIDES (L.) Britton
Scirpus cyperoides, L. Mant. II : 181. 1771.
Mariscus Sieberianus, Nees, Linnaea, 9': 286. 1834 (hyponym)
Mariscus cyperoides. Urban, Symb. Ant. II : 164. 1900.
Collected in Jamaica by Hart and by Wullschlaegel, as cited by Clarke. Introduced from Tropical Asia or Africa. Also in Trinidad.

24. CYPERUS TETRAGONUS, Ell. Bot. S. C. & Ga. I : 71. 1816.
Cyperus anceps, Liebm. Mex. Halvgr. 25. 1850.
Mariscus tetragonus, Clarke in Urban, Symb. Ant. I : 44. 1900.
Recorded by Clarke from Jamaica as collected by Wullschlaegel. Distribution : southeastern United States and Mexico.

25. CYPERUS CAYENNENSIS, (Lam.) Britton
Kyllinga cayennensis, Lam. Ill. I : 149. 1791.
Mariscus flavus, Vahl, Enum. II : 374. 1806.
Cyperus flavomariscus, Griseb. Fl. Br. W. I. 567. 1864.
Mariscus cayennensis, Urban, Symb. Ant. II : 165. 1900.
In fields and on banks, frequent. Vicinity of Constant Spring (Maxon 2155). Southeastern United States and Mexico to Patagonia.

26. CYPERUS SWARTZII (Dietr.) Boeckl.
Mariscus Swartzii, Dietr. Sp. Pl. II : 343. 1833.
Kyllinga filiformis, Sw. Prodr. 20. 1788. Not *Cyperus filiformis* Sw.
Cyperus caymanensis, Millsp. Field Col. Mus. Bot. II : 120. 1900.
Recorded by Grisebach and by Clarke. Jamaica Plants No. 1561,

in herb. Public Gardens (Rev. Bassett Key). Grand Cayman (Millspaugh 1334). Distribution: Jamaica, Haiti, Cuba, Guadaloupe.

27. CYPERUS GRANULARIS (Desf.) Britton
Kyllinga granularis, Desf.; Boeckl. Linnaea, XXXV: 432. 1867-68
Cyperus nanus, Boeckl. in Engler's Bot. Jahrb. I: 363. 1881. Not Willd. 1797.
Mariscus gracilis, Vahl, Enum. II.: 273. 1806. Not *Cyperus gracilis* R. Br.
Kyllinga filiformis, var. a, Griseb. Fl. Br. W. I. 568. 1864.

Jamaica (March 13, according to Clarke). Distribution: Haiti, Porto Rico, St. Martin, St. Croix.

28. CYPERUS TENUIS, Sw. Prodr. 20. 1788.
Mariscus tenuis, Clarke in Urban, Symb. Ant. II: 48. 1900.

Jamaica, collected by March and by Purdie. Distribution: Haiti and St. Croix.

29. CYPERUS NANUS, Willd. Sp. Pl. I: 272. 1796.
Schoenus capillaris, Sw. Prodr. 20. 1788. Not *Cyperus capillaris*, Koen.
Mariscus capillaris, Vahl, Enum. II: 372. 1806.
Kyllinga capillaris, Griseb. Kar. 120. 1857.

Jamaica (March 13, according to Clarke). Mr. Clarke cites this same collection number of March under *Mariscus gracilis*.

30. CYPERUS MUTISII (H. B. K.) Griseb. Fl. Br. W. I. 567. 1864.
Mariscus Mutisii, H. B. K. Nov. Gen. & Sp. I: 216. pl. 66. 1815.

Hillsides and banks at middle and higher altitudes. Cinchona (Underwood 424; Harris 9500; Shreve); near Gordon Town (Britton 13). Distribution: Haiti: Porto Rico: Mexico to Bolivia.

31. CYPERUS LIGULARIS, L. Amoen. Acad. V: 391. 1859.
Mariscus rufus, H. B. K. Nov. Gen. & Sp. I: 216. pl. 67. 1815.
Mariscus ligularis, Urban, Symb. Ant. II: 165. 1900.

Common along brackish marshes. Navy Island (Fredholm 3322). Grand Cayman (Millspaugh 1301). Widely distributed in the warm and tropical parts of America.

32. CYPERUS BRUNNEUS, Sw. Fl. Ind. Occ. I: 116. 1797.
Mariscus bruneus, Clarke in Urban, Symb. Ant. II: 51. 1900.

On sandy sea-beaches; also on the Cayman Islands. Distribution: sea-beaches and sand-dunes from Bermuda and Florida to Barbados and Central America.

33. CYPERUS CONFERTUS, Sw. Prodr. 20. 1788.
Mariscus confertus, Clarke in Urban, Symb. Ant. II: 50. 1900.

Banks and hillsides in the drier parts of the island. Near Hope (Harris 6641). Haiti: Porto Rico to Martinique; northern South America.

34. CYPERUS FILIFORMIS, Sw. Prodr. 20. 1788.
Torulinium filiforme, Clarke in Urban, Symb. Ant. II: 57. 1900.

Edges of marshes. Observed by us only near Balaclava (Marble

707), but obtained by the earlier collectors. Grand Cayman (Millspaugh 1296). Common in the West Indies.

35. CYPERUS FERAX, Rich. Act. Soc. Hist. Nat. Paris' I: 106. 1792.
Cyperus flexuosus, Vahl, Enum. II: 359. 1806.
Torulinium confertum, Hamilt. Prodr. Fl. Ind. Occ. 15. 1826.
Torulinium ferax, Urban, Symb. Ant. II: 165. 1900.

Common in swamps and along streams at low and middle elevations. Hartford, near Priestman's River (Maxon 2531); near St. Paul (Marble 699); Troy (Maxon 2930; Britton 471); Mona (Harris 8939). Widely distributed in warm and tropical parts of America.

36. CYPERUS VAHLII, (Nees) Steud. Syn. Pl. Cyp. 48. 1855.
Diclidium Vahlii, Nees in Mart. Fl. Bras. II: 53. 1843.
Cyperus flexuosus, Griseb. Pl. Cub. 238. 1866. Not Vahl. 1806.

Collected in Jamaica by Wilson as cited by Clarke; Jamaica Plants No. 844. Cuba; Haiti; Windward Islands.

37. CYPERUS SPECIOSUS, Vahl, Enum. II: 364. 1806.
Cyperus Michauxianus, Schultes in R. & S. Syst. II: Mant. 123. 1824.
Torulinium Michauxianum, Clarke in Urban, Symb. Ant. II: 56. 1900.

This species of Eastern North America is cited by Clarke as collected in Jamaica by W. Wright.

CYPERUS ALTERTNIFOLIUS, L., a widely cultivated ornamental species, native of Tropical Africa, has escaped from Castleton Gardens and become established along the Wag Water River as observed by Mr. William Harris.

3. ELEOCHARIS, R. Br. Prodr. Fl. Nov. Holl. I: 224. 1810.

Spikelet cylindric, scarcely or not at all thicker than the culm; scales coriaceous, not keeled
Culms terete, nodose — 1. *E. interstincta*
Culms angled, continuous — 2. *E. mutata*
Spikelet ovoid or oblong, thicker than the culm; scales membranous, keeled.
Style-branches 2; achene lenticular or biconvex
Upper sheath with a membranous hyaline limb; rootstock slender — 3. *E. flaccida*
Upper sheath 1-toothed; rootstock none — 4. *E. capitata*
Style-branches 3; achene 3-angled
Culms continuous
Culms setaceous or filiform
Achene cancellate; spikelet 1-4—flowered — 5. *E. retroflexa*
Achene smooth; spikelet 8-10—flowered — 6. *E. microcarpa*
Culms slender — 7. *E. albida*
Culms stout, pseudo-septate, constricted under the spikelet — 8. *E. geniculata*

Type species *Scirpus palustris*, L.

1. ELEOCHARIS INTERSTINCTA (Vahl) R. & S. Syst. II: 148. 1817.
Scirpus plantagineus, Griseb. Kar. 122. 1857.
Scirpus interstinctus, Vahl, Enum. II: 251. 1806.

Frequent in coastal marshes. Folly Point (Fredholm 3146). Very widely distributed in marshes from Rhode Island to temperate South America

2. ELEOCHARIS MUTATA (L.) R. & S. Syst. II: 155. 1817.
Scirpus mutatus, L. Amoen. Acad. V: 391. 1760.

Frequent or occasional in marshes. Near Ewarton (Harris 8513; Underwood 1861). Widely distributed in tropical America.

3. ELEOCHARIS FLACCIDA (Spreng.) Urban, Symb. Ant. II: 165. 1900.
Scirpus flaccidus, Spreng. Tent. Suppl. 3. 1828.
Scirpus ochreatus, Griseb. Fl. Br. W. I. 570. 1864.
Eleocharis ochreata, Nees, Linnaea, IX: 294. 1834.

In a brook, Troy (Britton 458); near Troy (Harris 8553). Widely distributed in tropical and warm-temperate America.

4. ELEOCHARIS CAPITATA (L.) R. Br. Prodr. 225. 1810.
Scirpus capitatus, L. Sp. Pl. 48. 1753.

In wet places, common at lower elevations. Near Annatto Bay (Maxon 1966); Rockfort (Britton 788; Harris 9380, 9565); Temple Hall (Harris 9389). In all tropical and subtropical regions.

5. ELEOCHARIS RETROFLEXA (Poir.) Urban, Symb. Ant. II: 165. 1900.
Scirpus retroflexus, Poir. in Lam. Encycl. VI: 753. 1804.
Eleocharis Chaetaria, R. & S. Syst.. II: 154. 1817.

Near Ewarton, around edges of a pond (Harris 8512; Underwood 1862; in a brook, Troy (Britton 451). Nearly throughout the West Indies and tropical South and Central America.

6. ELEOCHARIS MICROCARPA, Torr. Ann. Lyc. N. Y. III: 312. 1836.
Eleocharis minima, Kunth, Enum. II: 139. 1837.

Reported from Jamaica by Clarke, as collected by Purdie. Distributed from the southern United States and Mexico and the West Indies to Brazil. Torrey's type specimens were from New Orleans; the plant of the Atlantic United States from New Jersey southward which has been referred to this species is *E. Torreyana*, Boeckl.

7. ELEOCHARIS ALBIDA, Torr. Ann. Lyc. N. Y. III: 304. 1836.

Jamaica (Mac Nab, according to Clarke). Reported from Bermuda; otherwise known only from the south-eastern United States and Mexico.

8. ELEOCHARIS GENICULATA (L.) R. & S. Syst. II: 150. 1817
Scirpus geniculatus, L. Sp. Pl. 48. 1753.
Scirpus constrictus, Griseb. Kar. 122. 1857.

Common in marshes and ditches up to 1300 m. altitude. Near Castleton (Underwood 131): River Head near Ewarton (Underwood 1867); Content Road to Cinchona (Underwood 159); near Balaclava (Marble 913); Hardware Gap (Nichols 97). Tropical America. Jamaica is the type locality of this species.

4. STENOPHYLLUS, Raf. Neog. 4. 1825.

[BULBOSTYLIS, Kunth, Enum. II: 205. 1837.]

Leaves narrowly linear, 1.5 cm. long, or reduced nearly to sheaths; achene narrowly obovoid — 1. *S. subaphyllus*

Leaves setaceous; achene broadly obovoid — 2. *S. capillaris*

Type species, *Scirpus stenophyllus*, Ell.

1. STENOPHYLLUS SUBAPHYLLUS (Clarke) Britton

Bulbostylis subaphylla, Clarke in Urban, Symb. Ant. II: 86. 1900.

Summit of Bull Head Mountain (Underwood 3364). Otherwise known only from Cuba (C. Wright 1533, in part).

2. STENOPHYLLUS CAPILLARIS (L.) Britton, Bull. Torr. Club. XXI: 30. 1894.

Scirpus capillaris, L. Sp. Pl. 49. 1753.

Bulbostylis capillaris, Clarke in Hook. f. Fl. Br. Ind. VI: 652.

Recorded from Jamaica by Clarke as collected by Wullschlaegel; otherwise not known from the island. Common in the Eastern United States.

5. FIMBRISTYLIS, Vahl, Enum. II: 285. 1806.

Style 2-cleft
- Achene longitudinally ribbed — 1. *F. diphylla*
- Achene reticulated
  - Leaves nearly or quite as long as the culm; scales of the spikelets chestnut-brown — 2. *F. spadicea*
  - Leaves much shorter than the culm; scales of the spikelets pale brown or greenish.
    - Leaves very short; spikelets about 1 cm. long — 3. *F. ferruginea*
    - Leaves half as long as the culm; spikelets 3-6 mm. long — 4. *F. glomerata*

Style 3-cleft — 5. *F. complanata*

Type species, *Fimbristylis acuminata*, Vahl.

1. FIMBRISTYLIS DIPHYLLA (Retz.) Vahl, Enum. II: 289. 1806.

Scirpus diphyllus, Retz. Obs. V: 15. 1789.

Fimbristylis laxa , Vahl, loc. cit. 292. 1806.

Fimbristylis brizoides, Nees, Linnaea, IX: 290. 1834.

In fields and on banks, frequent. Near Port Antonio (Earle 624; Fredholm 3301; Britton 866); near Troy (Harris 8707; Maxon 2810); Temple Hall (Harris 9391); Cinchona (Harris 9495). Widely distributed in tropical regions.

2. FIMBRISTYLIS SPADICEA (L.) Vahl, Enum. II: 294. 1806.

Scirpus spadiceus, L. Sp. Pl. 51. 1753.

Common in coastal marshes. Port Antonio (Britton 860). Jamaica is the type locality for this species (Sloane, I: 118, *pl. 76, f. 2*). Distribution: West Indies.

3. FIMBRISTYLIS FERRUGINEA (L.) Vahl, Enum. II: 291. 1806.

Scirpus ferrugineus, L. Sp. Pl. 50. 1753.

Common in coastal marshes. Port Antonio (Britton 906). Jamaica is the type locality. Distribution: West Indies.

4. FIMBRISTYLIS GLOMERATA (Retz.) Urban, Symb. Ant. II: 166. 1900.

Scirpus glomeratus, Retz. Obs. 4. 11. 1786.
Fimbristylis spathacea, Roth, Nov. Sp. 24. 1821.

Marshes, Port Antonio (Britton 863); roadside ditch, Rockfort (Britton 784; Harris 9318) Not hitherto recorded from Jamaica.

5. FIMBRISTYLIS COMPLANATA (Retz.) Link, Hort. Berol. I: 292. 1827.

Scirpus complanatus, Retz. Obs. V: 14. 1789.
Scirpus amentaceus, Griseb. Kar. 123. 1857.

Coastal marshes between Annotta Bay and Buff Bay (Britton 845) Widely distributed in tropical regions.

6. ABILDGAARDIA, Vahl, Enum. II: 296. 1806.

Type species, *Cyperus monostachyus*, L.

ABILDGAARDIA MONOSTACHYA, (L.,) Vahl Enum. II: 296 1806.

Cyperus monostachyus, L. Mant. 180. 1771.
Fimbristylis monostachya, Hassk. Pl Jav. Rar. 61. 1848.

Frequent on dry banks and in fields. Near Port Antonio (Fredholm 3277); Troy (Britton 439); between Potsdam and Lover's Leap (Britton 1138). Widely distributed in tropical regions.

7. SCIRPUS, L. Sp. Pl. 47. 1753.

Culms tall, stout	
Spikelets umbelled; culms terete	1. *S. validus*
Spikelets capitate; culm trigonous	2. *S. Olneyi*
Culms filiform, low	3. *S. caespitosus*

Type species, *Scirpus lacustris*, L.

1. SCIRPUS VALIDUS, Vahl, Enum. II: 268. 1806.

Frequent in coastal marshes. Ferry River (Fawcett & Harris 8089; Britton 398). Common in warm and tropical America.

2. SCIRPUS OLNEYI, A. Gray, Boston Journ. Nat Hist. V: 238. 1845.

Recorded by Clarke as collected in Jamaica by Bromfield. Distribution: United States and West Indies.

3. SCIRPUS CAESPITOSUS, L. Sp. Pl. 48. 1753.

This species of high mountains of the north temperate zone, is recorded by Boeckeler in Linnaea, XXXVI: 488, as occurring in Jamaica, but this is almost certainly an error.

8. ERIOPHORUM, L. Sp. Pl. 52 1753.

Type species, *Eriophorum vaginatum*, L.

1. ERIOPHORUM POLYSTACHYUM, L. Sp. Pl. 52. 1753.

Eriophorum angustifolium, Roth, Neue Beitr. 94. 1802.

Jamaica (W. Wright, according to Clarke). Known otherwise only from cold temperate regions; the identity of the specimen cited is open to suspicion.

9. FUIRENA Rottb. Descr. et Ic. 70. 1773.

Heads of spikelets numerous in a long panicle; leaves 8-12 mm. wide	1. *F. umbellata*
Heads of spikelets only 1 to 5; leaves 4 mm. wide or less	2. *F. squarrosa*

Type species, *Fuirena umbellata*, Rottb.

1. FUIRENA UMBELLATA, Rottb. Descr. et Ic. 70. 1773. Frequent in coastal marshes. Near Cold Harbour, east of Port Antonio (Britton 900). Widely distributed in tropical regions.

2. FUIRENA SQUARROSA, Michx. Fl. Bor. Am. I: 37. 1803. Jamaica, according to Vahl, but not found on the island by recent collectors. The species is widely distributed in the eastern United States and is reported from Cuba.

10. DICHROMENA, Michx. Fl. Bor. Am. I: 37. 1803.

Bracts of the involucre ciliate at the base
  Spikelets capitate-spicate; bracts white toward the base 1. *D. ciliata*
  Spikelets 1-5; bracts mostly green throughout 2. *D. radicans*
Bracts of the involucre not ciliate 3. *D. colorata*

Type species, *Dichromena leucocephala*, Michx.

1. DICHROMENA CILIATA, Vahl, Enum. II: 240. 1806.
Rhynchospora pura, Griseb. Fl. Br. W. I. 577. 1864.
Grassy banks and meadows; frequent at low and middle elevations. Brandon Hill (Thompson 8101); Mansfield, Bath (Nichols 192); near Port Antonio (Fredholm 3021), Troy (Britton 447). Widely distributed in Tropical America.

2. DICHROMENA RADICANS, Schl. & Cham. Linnaea, VI: 28. 1831.
Rhynchospora Persooniana, Griseb. Fl. Br. W. I. 377. 1864
Meadow, near Hollymount (Britton 769). Widely distributed in Tropical America.

3. DICHROMENA COLORATA (L.) A. S. Hitchc. Rep. Mo. Bot. Gard. IV: 141. 1893.
Schoenus coloratus, L. Sp. Pl. 43. 1753.
Rynchospora stellata, Griseb. Kar. 123. 1857.
Dichromena leucocephala, Michx. Fl. Bor. Am. I: 37. 1803.
Recorded from Jamaica by Grisebach and by Clarke and represented in the herbarium of the Public Gardens. Grand Cayman (Millspaugh 1375). Distribution: Southern United States, West Indies and Central America.

11. RYNCHOSPORA Vahl, Enum. II: 229. 1806.

Style long, its branches much shorter than the lower undivided part
  Spikelets densely capitate 1. *R. cyperoides*
  Spikelets in panicled clusters, not densely capitate
    Tubercle nearly or quite twice as long as the achene 2. *R. Eggersiana*
    Tubercle shorter than the achene, or but little longer.
      Bristles about as long as the achene or longer 3. *R. corymbosa*
      Bristles obsolete or none
        Spikelets fascicled, leaves 1.5-3 mm. wide 4. *R. elongata*
        Spikelets not fascicled, the clusters loose; leaves 4 mm. wide 5. *R. polyphylla*

Style short, its branches about as long as the lower undivided part.
Bristles none
Spikelets 1-2 mm. long 6. *R. micrantha*
Spikelets 3-6 mm. long
Achene not 3-toothed 7. *R. Berterii*
Achene 3-toothed at the summit 8. *R. setacea*
Bristles present, upwardly barbed
Achene smooth 9. *R. fascicularis*
Achene cancellate 10. *R. cephalotes*
Achene transversely wrinkled
Bristles shorter than the achene; spikelets filiform-peduncled 11. *R. rariflora*
Bristles as long as the achene or longer; spikelets not filiform-peduncled
Achene not stipitate; spikelets about 3 mm. long 12. *R. glauca*
Achene stipitate; spikelets 5-7 mm. long 13. *R. jubata*

Type species, *Rynchospora aurea*, Vahl.

1. RYNCHOSPORA CYPEROIDES (Sw.) Mart. Denksch. Acad. Wiss. Muench. VI: 149. 1816-17.

Schoenus cyperoides, Sw. Prodr. 19. 1788.

Meadow between Oxford and Wallingford (Britton 692); Oxford (Harris 9441). Not recorded by Clarke from Jamaica, but duly recorded by Grisebach. Widely distributed in Tropical America.

2. RYNCHOSPORA EGGERSIANA, Boeckl. Cyp. Nov. II. 26. 1890.

Rynchospora florida, Griseb. Fl. Br. W. I. 575. 1864.
Rynchospora aristata, Clarke in Urban, Symb. Ant. II: 115, in part, 1900.

Common in mountain woods. St. Catherine's Peak (Eggers 3596, type; Blue Mountain Peak (Shreve); John Crow Peak (Britton 276); Morce's Gap (Nichols 42; Britton 917); Cinchona (Underwood 468; Shreve; Britton 63). Endemic. Differs from the Mexican and South American *R. aristata*, Boeck. by its shorter tubercle, longer bristles and more conspicuously cancellate achene.

3. RYNCHOSPORA CORYMBOSA (L.) Britton, Trans. N. Y. Acad. Sci. XI: 85. 1902.

Scirpus corymbosus, L. Sp. Pl. 76. 1753.
Rynchospora aurea, Vahl, Enum. II. 229. 1806.
Schoenus surinamensis, Rottb. Descr. et Ic. 68. 1773.
Rynchospora surinamensis, Nees, Linnaea, IX: 297. 1834.

Marshes, Port Antonio (Britton 859). Not otherwise known from Jamaica, except as cited by Grisebach, collected long ago by Swartz, and not referred to by Clarke.

4. RYNCHOSPORA ELONGATA, Boeckl. Cyp. Nov. I: 261. 1888.

On shaded banks and in bogs at higher elevations. New Haven Gap (Shreve); near Cinchona (Britton 132); Morce's Gap (Britton 914). John Crow Peak (Britton 196); Sir John Peak (Britton 279); slopes below Sir John Peak (Harris 9550). Distribution: Jamaica; Porto Rico; Guadaloupe.

5. RYNCHOSPORA POLYPHYLLA, Vahl, E.num. II. 230. 1806.
Schoenus polyphyllus Vahl, Eclog. Am. II: 5. 1798.
Banks, hillsides and moist woods, common at higher and middle elevations. Cuna Cuna Pass (Fredholm 3240); Cinchona (Shreve; Harris 9502); John Crow Peak (Nichols 44); Content Gap (Britton 33); near Moore Town (Marble 851); Bull Head Mountain (Underwood 3379); Troy (Maxon 2817). Southern West Indies; Central America to Venezuela.

6. RYNCHOSPORA MICRANTHA, Vahl, Enum. II: 231. 1806.
Edge of a brook, Troy (Britton 457). Widely distributed in Tropical America, and occurs also in Tropical Africa.

7. RYNCHOSPORA BERTERII (Spreng.) Clarke, in Urban, Symb. Ant. II: 119. 1900.
Schoenus pusillus, Sw. Prodr. 20. 1788.
Hypolytrum Berterii, Spreng. Neue Entd. I: 241. 1820.
Rynchospora pusilla, Griseb. Kar. 123. 1857. Not Curtis.
On moist banks, shaded rocks and along brooks and ditches at low and middle elevations. Near Troy (Harris 8691, 9420); Tyre (Britton 911); Oxford (Britton 428); Port Antonio (Fredholm 3114) Distribution: West Indies south to Guadaloupe.

8. RYNCHOSPORA SETACEA (Berg.) Boeckl. Vidensk. Medd. Kjob. 1869-70: 159.
Schoenus setaceus, Berg. Act. Helv. VII: 130. 1772.
Rynchospora tenerrima, Spreng. Syst. Cur. Post. 26. 1827.
Rynchospora Spermodon, Griseb. Fl. Br. W. I. 576. 1864.
Borders of marshes. Port Antonio (Britton 877); Moore Town (Marble 849). West Indies and tropical South America.

9. RYNCHOSPORA FASCICULARIS (Michx.) Vahl, Enum. II: 234. 1806.
Schoenus fascicularis, Michx. Fl. Bor. Am. I: 37. 1803.
Summit of Bull Head Mountain (Underwood 3364b); previously collected in Jamaica by Purdie. Distribution; Southeastern United States, Cuba, Haiti, Porto Rico.

10. RYNCHOSPORA CEPHALOTES (L.) Vahl, Enum. II: 237. 1806.
Scirpus cephalotes, L. Sp. Pl. Ed. 2, 76, 1762.
Jamaica (Masson, according to Clarke). Tobago; Trinidad; Central and South America.

11. RYNCHOSPORA RARIFLORA, (Michx.) Ell. Bot. S. Car. & Ga. I: 58. 1816.
Schoenus rariflorus, Michx. Fl. Bor. Am. I: 35. 1803.
Bull Head, Clarendon (Hart). The only station known for this species south of the Isle of Pines. Southeastern United States and Cuba.

12. RYNCHOSPORA GLAUCA, Vahl, Enum. II. 233. 1806.
Rynchospora gracilis, R. & S. Syst. II: 85. 1817.
Summit of Bull Head Mountain (Underwood 3364a). 'Widely distributed in Tropical America.

13. RYNCHOSPORA JUBATA, Liebm. Vidensk. Selsk. Skr. V. 2: 254. 1851.
Rynchospora Marisculus Nees, Linnaea, IX: 297, hyponym. 1834.
Cited from Jamaica by Clarke as collected by Wilson. West Indies and Central and South America.

12. **CLADIUM**, P. Browne; Crantz, Inst. I: 362. 1766.
Type species, *Cladium jamaicense*, Crantz.

1. **CLADIUM JAMAICENSE**, Crantz, Inst. I: 362. 1766.
Cladium occidentale, R. & S. Syst. I: 284. 1817.

Common in coastal marshes. Ferry River (Harris 8632). Common in marshes throughout the West Indies and the southern United States.

Cladium Mariscus (L.) R. Br., of Europe, is in my opinion specifically distinct.

13. **SCLERIA**, Berg. Vet. Acad. Handl XXVI: 142. 1765.
Type species, *Scleria Flagellum nigrorum*, Berg.

- A. Hypogynium present
  - a. Margin of the hypogynium neither ciliate nor fimbriate
    - Ligule large, its margins scarious — 1. *S. reflexa*
    - Ligule short, ovate
      - Culm spreading, branched — 2. *S. secans*
      - Culm erect
        - Panicle reddish-purple; achene purple or purplish — 3. *S. melaleuca*
        - Panicle brown-green; achene white or whitish — 4. *S. pterota*
  - b. Margin of the hypogynium ciliate, ciliolate or fimbriate
    - Achene 2 mm. long or less — 5. *S. microcarpa*
    - Achene 2.5-3 mm. long
      - Margin of the hypogynium finely ciliolate or nearly eciliate — 6. *S. cubensis*
      - Margin of the hypogynium densely long-ciliate — 7. *S. Grisebachii*
- B. Hypogynium wanting
  - Inflorescence glomerate-spicate — 8. *S. hirtella*
  - Inflorescence of several loose elongated clusters — 9. *S. lithosperma*

1. **SCLERIA REFLEXA**, H. B. K. Nov. Gen. & Sp. I: 232. 1815.

Climbing or trailing. Hope (Harris 7084); Port Antonio (Fredholm 3338); submit of Bull Head Mountain (Underwood 3378). Haiti to Trinidad; Mexico to Brazil.

2. **SCLERIA SECANS** (L.) Urban, Symb. Ant. II: 169. 1900.
Schoenus secans L. Syst. Ed. 10. 865. 1759.
Scleria Flagellum, Sw. Prodr. 18. 1788.
Scleria Flagellum nigrorum, Berg. Vet. Acad. Handl. XXVI: 144. 1765.

Jamaica, collected by W. Wright, according to Clarke (Sloane, I: *pl.* 77, *f.* 1). Northern South America.

3. **SCLERIA MELALEUCA**, Schl. & Cham. Linnaea, VI: 29. 1831.

Vicinity of Troy (Maxon 2874); banks, Content Gap (Britton 42); banks near Cold Harbour (Britton 882). West Indies, Central America; Tropical South America.

4. **SCLERIA PTEROTA**, Presl, in Oken Isis, XXI: 263. 1828.
Scleria pratensis, Nees in Mart. Fl. Bras. II: 179. 1843.

Moist banks and thickets and along streams, frequent at middle elevations. Near Gordon Town (Britton 8); near St. Paul (Marble 701); Troy (Britton 453); summit of Bull Head Mountain (Underwood 3409). Widely distributed in Tropical America.

5. SCLERIA MICROCARPA, Nees, Linnaea, IX: 302. 1834.
Scleria foliosa, Sauvalle, Ann. Acad. Habana, VIII: 154. 1871. Not Rich.
Scleria microcarpa var. *foliosa,* Clarke in Urban, Symb. Ant. II: 149. 1900.

Damp field near Port Antonio (Fredholm 3298). Not otherwise known from Jamaica. The var foliosa, Clarke, is said to differ from the species in the less ciliate margin of the disk, but this appears to be a very variable character, and I do not regard it as important in this plant. Widely distributed in Tropical America.

6. SCLERIA CUBENSIS, Boeckl. Cyp. Nov. II: 42. 1890.
Scleria microscarpa, Griseb. Cat. Pl. Cuba, 248, 1866 Not Nees.
Scleria microcarpa var. *eciliata,* Clarke in Urban, Symb. Ant. II: 149. 1900.

Moist rocky woods, Tyre (Britton 538); apparently not rare. Culms 4 m. long. Cuba; Haiti; Porto Rico.

7. SCLERIA GRISEBACHII, Clarke in Urban, Symb. Ant. II 151. 1900.
Scleria mitis, Griseb. Fl. Br. W. I. 578. 1864. Not Berg. 1765.

Marsh, Port Antonio (Britton 861). Plant 2 m. high. Porto Rico to Martinique.

8. SCLERIA HIRTELLA, Sw. Prodr. 19. 1788.

Summit of Bull Head Mountain (Underwood 3373); Jamaica Plants No. 2017 in Herbarium Public Gardens. Not otherwise known from Jamaica. Widely distributed in Tropical America.

9. SCLERIA LITHOSPERMA (L.) Sw. Prodr. 18. 1788.
Scirpus lithospermus, L. Sp. Pl. 51. 1753.
Scleria filiformis, Sw. Prodr. 19. 1788.

On hillsides in the xerophytic regions. Mona Hill (Britton 372); near Malvern (Britton 1902); Long Mountain (Harris 9610). Widely distributed in both New and Old World tropics.

14. UNCINIA, Pers. Syn. II: 534. 1807.
Type species, *Carex uncinata,* L.

1. UNCINIA HAMATA (Sw.) Urban, Symb. Ant. II: 169. 1900.
Carex hamata, Sw. Prodr. 18. 1788.
Uncinia jamaicensis, Pers. Syn. II: 534. 1807.

In forests at high elevations. John Crow Peak (Nichols 43); Clyde River Valley below Cinchona (Underwood 438); New Haven Gap (Maxon 2692); Cinchona (Shreve) road to Vinegar Hill (Harris 8435); New Haven Gap to Vinegar Hill (Britton 161). Distribution: Jamaica; Central America to Brazil.

15. CAREX, L. Sp. Pl. 972. 1753.

Terminal spike all staminate
  Perigynium long-beaked — 1. *C. Underwoodii*
  Perigynium beakless — 2. *C. hinnulea*

Terminal spike pistillate at base or apex or at both
  Spikes linear-cylindric 3. *C. virescens*
  Spikes ovoid or oblong
    Perigynium glabrous 4. *C. cladostachya*
    Perigynium rough-pilose. 5. *C. scabrella*

Type species, *Carex pulicaris*, L.

1. CAREX UNDERWOODII, Britton. Torreya, V: 10. 1905.
Carex hystericina, Clarke in Urban, Symb. Ant. II 159. 1900. Not Schkuhr. 1806.

In sphagnum, Salt Hill Pond (Underwood 158); Petersfield Pond Guava Ridge (Shreve). Endemic.

2. CAREX HINNULEA, Clarke in Urban, Symb. Ant. II: 159. 1900.

The only specimen known of this species is preserved in the Goodenough herbarium, and its collector is not recorded.

3. CAREX VIRESCENS, Schkuhr, Riedgr. II: 45. 1806.

This common species of Eastern North America is also represented in the Goodenough herbarium by a specimen purporting to be from Jamaica, as recorded by Mr. Clarke.

4. CAREX CLADOSTACHYA, Wahl. Kong. Vet. Acad. Handl. XXIV: 149. 1803.

On banks and hillsides at high elevations. Cinchona (Shreve): Morce's Gap (Nichols 26; Britton 179). Mountains of the West Indies; Mexico to Bolivia.

5. CAREX SCABRELLA, Wahl. Kong. Vet. Acad. Handl. XXIV: 149, 1803.

Grassy banks and thickets. Between Chestervale and Silver Hill Gap (Britton 350); Mona Hill (Britton 363). Distribution: mountains and hills of Jamaica, Cuba and Haiti.

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THE GENUS ANTROPHYUM—I

SYNOPSIS OF SUBGENERA, AND THE AMERICAN SPECIES

BY RALPH CURTISS BENEDICT

NEW YORK
1907

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 34: 445–458. 1907.]

The genus Antrophyum — I. Synopsis of subgenera, and the American species

RALPH CURTISS BENEDICT

The genus *Antrophyum*, as known at present, comprises more than thirty species of wide distribution in the tropics. Of this number, nine are confined to America, ranging from Mexico and Cuba on the north to Bolivia and southeastern Brazil on the south. The Old World species range from eastern Polynesia to Japan and China, south to New Guinea, the Mascarene Islands and Madagascar, and across Africa to the island of Fernando Po on the west coast.

The genus was established in 1824 by Kaulfuss,* who named six species, but recognized three more in a footnote. Three of the nine were American. The first species to be figured was the Old World *A. reticulatum* (Forster) Kaulfuss,† which may be considered as the type of the genus. Only one of the nine, the American *A. lanceolatum*, was known to Linnaeus.

The nine original species had been described under the Linnaean genus, *Hemionitis*, with which, however, they have very little affinity. They are probably more closely related to *Loxogramme* Presl. Blume recognized this when he classified several species properly belonging to the latter genus under *Antrophyum*,‡ and Presl placed one species of *Antrophyum* with *Loxogramme*.§

When the present work was commenced, it was intended to include the entire genus, but the material at hand was not sufficiently complete for an exhaustive study of all the species, and in this paper only the American species are treated extensively. Complete descriptions of all the species can not be given without comparative study of the types in the European herbaria. Further field work is also necessary.

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* Enum. Fil. 197. 1824.

† Schkuhr, Crypt. Gewäch. 6. *pl. 6.* 1805.

‡ Flora Jav. Fil. 84–87. *pl. 36, 37.* 1828.

§ Tent. 215. 1836.

The herbarium of the New York Botanical Garden has furnished most of the material studied, but loans from the Eaton Herbarium and from the U. S. National Herbarium have been of great assistance, and hearty thanks are hereby tendered Professor Evans and Mr. Maxon for their aid. To Dr. Christ also, thanks are due for a loan of type material of one of his species.

ANTROPHYUM Kaulf. Enum. Fil. 197. 1824

Plants epiphytic or on rock (rarely in soil); rhizomes rather stout, short-creeping or suberect, usually clothed with a dense mass of fuzzy roots, together with the bases of old fronds; apical buds and stipe-bases covered with delicate deciduous clathrate scales whose cell-walls may be smooth or papillose; fronds cespitose, glabrous, membranous, coriaceous, or fleshy, sessile or with alate stipes; costas complete or vestigial, the secondary venation reticulate, without included veinlets, of long costal areolae and shorter, frequently divergent lateral ones, which may be closed along the margin, or open in free veinlets: sporangia in either simple or branching lines mostly along the longitudinal veins, free or more or less interconnected, or completely reticulated and on all the veins (in mature fronds), superficial or immersed in grooves; indusia wanting; paraphyses of various shapes may be mixed with the sporangia.

Various methods have been used to divide the genus into groups. Those based on gross foliar or soral differences alone have not been successful, as they have included in the same sections species which differed in fundamental characters such as spore-form. At the suggestion and aided by the advice of Dr. Underwood, to whom sincere thanks are due, the writer has endeavored to find out whether microscopic characters would furnish adequate means of separation. The results have been extremely satisfactory. Part of the scheme given below is based on that used by Fée in his monograph of the genus,* but it is very much modified and extended, and the characters are chosen so as to show natural relationships. By a combination of the characters of soriation and spore-form, separation into four subgenera is readily made. The use of microscopic characters may be carried still further. The Asiatic species are easily divided into groups and to some extent, into species according to the shape of the soral paraphyses. By this means certain species, otherwise easily confused, may be separated without difficulty.

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* Mém. Foug. 4: 39–52. 1852.

Four of the five African species, which possess several well-marked distinctive characters, have been separated as a new subgenus, **Antrophyopsis.*** The only other African species known, *A. immersum*, seems to belong rather with the type section.

The terms "diplanate" and "triplanate" have been used for the spores instead of the usual "reniform" and "sphaero-tetrahedral" as being of more exact significance, since they relate not to mere variable form but to systems of spore-cleavage.

Synopsis of subgenera

Soriation in mature fronds completely reticulated, superficial or slightly raised; spores diplanate; paraphyses present; costa vestigial, marginal veinlets free to the edge of the frond; stipe-scale cell-walls papillose (all?).
§ **Antrophyopsis** (African) *

Soriation of simple or branched lines which may be more or less interconnected but never completely reticulated, superficial or immersed in grooves; spores diplanate or triplanate, paraphyses present or absent; costa complete or vestigial, marginal veinlets usually anastomosing with the anterior veinlets to form closed areolae; stipe-scale cell-walls smooth.
  Spores diplanate, paraphyses pyriform; costa complete.
  § SCOLIOSORUS (American)
  Spores triplanate.
    Sporangia in three or four long grooves on each side of the complete costa and parallel to it; paraphyses wanting. § POLYTAENIUM (American)
    Sporangia, except in the three narrowest forms, in branched lines, more or less connected; paraphyses present or absent; costa complete or vestigial.
    § EUANTROPHYUM
      Paraphyses wanting; costa complete or nearly so.
      Costata (American)
      Paraphyses present; costa vestigial. *Ecostata* (Old World)

The American section of the genus *Antrophyum* comprises nine species separable into three subgenera as noted in the group synopsis, according to (1) soriation, and (2) spore-form. All are alike in having a complete or nearly complete costa, a character distinguishing them from all the Old World forms, some of which, however, approach this condition. A still more sharply distinctive character, if *A. ensiforme* be excluded, is the absence of paraphyses, which are found in all the Old World species.

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* Type, *A. Boryanum* (Willd.) Spr.

On the basis of this character together with spore-form, *A. ensiforme* Hooker with diplanate spores may be separated from the others which lack paraphyses and have triplanate spores. Moore's genus *Scoliosorus* was based on this species, but on the strength of a non-existing character inferred from Hooker's incomplete description. The characters here given, however, and a slight but decided difference in soriation are sufficient to separate it at least as a subgenus.

Using soriation as a basis, Desvaux in 1827 established a new genus, *Polytaenium*, with *A. lineatum* as type. The sporangia in this species are in three or four long straight deep grooves on each side of the costa, and parallel to it, an arrangement considerably different from the normal American type which consists of series of divergent branching lines, superficial or only slightly immersed. In some of the broadest forms of *A. lineatum*, however, the type of soriation approaches the normal, and on the whole, the similarities seem greater than the differences, which are satisfied by recognition as a subgenus.

The remainder of the species belong to the costate section of *Euantrophyum*. After we eliminate *A. lanceolatum*, which is easily distinguishable, six species remain, two of which are described here for the first time, and one other which has never been accepted. These three are based on material originally identified as *A. subsessile* Kunze (*A. brasilianum* (Desv.) C. Chr.), but such reference is not justified. The six species form a group of coördinate forms, no one of which is entitled to stand as representative of the others. If *A. discoideum*, for example, be refused recognition, then logically *A. cayennense* which has always been recognized must also be referred to *A. brasilianum*. The fact that in the most superficial and easily determined character, outline, *A. discoideum* resembles *A. brasilianum* more closely, is not a sufficient reason for denying its validity. In reality it is less closely related to the latter fern than is *A. cayennense*, which shows its affinity in a coriaceous texture and closed marginal areolae, and sometimes even in outline.

Reasons of value equal to those just given for recognizing *A. discoideum* can be given for the admission of the other species treated here. Indeed, further field work may show that two or three other variant forms to which reference is made under the species concerned, are also entitled to specific rank.

The American species may be separated as follows:

- Spores diplanate; paraphyses pyriform (*Scoliosorus*). 1. *A. ensiforme.*
- Spores triplanate; paraphyses wanting.
  - Sporangia in long simple grooves parallel to costa (*Polytaenium*). 2. *A. lineatum.*
  - Sporangia not in long simple grooves (*Euantrophyum*).
    - Areolar axes longitudinal. 3. *A. lanceolatum.*
    - Areolar axes divergent.
      - Soral lines slightly sunken; marginal venation mostly closed in short areolae with few free veinlets.
        - Fronds coriaceous, margins reflexed.
          - Fronds oblanceolate, rather thick, opaque. 4. *A. brasilianum.*
          - Fronds elliptic, thin, translucent. 5. *A. cayennense.*
        - Fronds not coriaceous, margins flat; fronds oblong, long-acute. 6. *A. Dussianum.*
      - Soral lines superficial; marginal venation of open free veinlets.
        - Fronds broadly oblanceolate, short-stiped, thick. 7. *A. Jenmani.*
        - Fronds elliptic-lanceolate, sessile. 8. *A. anetioides.*
        - Fronds oblong or oblanceolate, subsessile, thin. 9. *A. discoideum.*

1. ANTROPHYUM ENSIFORME Hook.; Benth. Pl. Hartweg. 73. 1841. (Type from Mt. Totontepeque, Mexico.)

Antrophyum falcatum Mart. & Gal. Mém. Foug. Mex. 49. *pl. 12.* 1842.

Antrophyum carnosum Liebm. Vid. Selsk. Skr. V. **1**: 161. 1849.

Antrophyum Galeottii Fée, Mém. Foug. **4**: 51. *pl. 5. f. 4.* 1852.

Scoliosorus ensiformis Moore, Ind. Fil. xxix. 1857.

Dictyogramme ensiformis Trev. Atti Ist. Ven. V. **3**: 592. 1877.

Spores diplanate, paraphyses pyriform, brown or yellow, on slender pedicels of various lengths which may arise singly or in clusters from a thickened basal cell; sporangia in simple or usually only once-forked, oblique, free, superficial lines along each side of the frond; fronds narrowly oblong, often curved, tapering very gradually below to a sessile base, less gradually above to a narrowly acute apex, thin, rather flaccid, 17 × 1.1–50 × 2.7 cm. margins reflexed, slightly repand; areolae in branching rows divergent from the complete costa, open along the margin; costa and areolation superficially indistinct.

Mexico to Costa Rica.

Antrophyum ensiforme occupies a rather anomalous position in the genus. Moore in 1857 made it the basis of a new genus, *Scoliosorus*, giving the following reasons based on Hooker's description and figure. "This plant having neither netted veins nor netted sori, cannot possibly belong to *Antrophyum*." His misapprehension regarding the venation was due to the fact that in the original description no evidence of a secondary venation was shown.

But a distinct difference in soriation really exists. In *Euantrophyum*, the soriation consists of series of lines which usually branch several times, and may anastomose considerably. In immature fronds or in the narrowest specimens, the lines may be simple, but the relationship is obvious. In *Scoliosorus*, the soral lines are simple or usually only once-forked, and at a glance appear different from the normal type, although probably derived from it.

Another distinctive character is found in the paraphyses which are present in no other American species. These, however, do not differ essentially from one type found on some of the Old World species and may be indicative of a paraphysate ancestry for all the present species.

The character of greatest differential value known at present is found in the diplanate spores which entitle the species at least to rank as a subgenus. Judging from external characters, anatomical differences exist as well which would further distinguish it from the typical species.

2. ANTROPHYUM LINEATUM (Sw.) Kaulf. Enum. Fil. 199. 1824.
Hemionitis lineata Sw. Prodr. 129. 1788. (Type from Jamaica.)
Vittaria lanceolata Sw. Gesell. Naturf. Freund. Neue Schr. 2: 133. *pl.* 7. *f.* 2. 1799.
Polytaenium laceolatum Desv. Prodr. 174. 1827.
Loxogramme lineata Presl, Tent. 215. 1836.
Polytaenium lineatum J. Sm. Jour. Bot. Hook. 4: 68. 1841.

Spores triplanate; paraphyses wanting; sporangia in three or four long grooves on each side of and parallel to the costa, rarely interconnected: fronds linear-lanceolate, 43 × 1 cm. and 43 × 1.5 cm. (maximum), long-tapering, sessile, membranous; areolae long and narrow, axes longitudinal, cross-veinlets transvese; venation indistinct.

West Indies and Mexico, south to Bolivia. Altitude: 500–1000 meters.

This is the most widely distributed of all the American species of *Antrophyum*. It is easily distinguished from *A. lanceolatum*, with which it is often associated, by its long straight soral grooves. In the broadest fronds, besides the longitudinal grooves, a series of short divergent ones may occur along each margin. One frond was seen which was intermediate between *A. lanceolatum* and *A. lineatum* in soriation and general appearance.

It is frequently referred to as a close relative of *Vittaria*, but it is really no more closely related than other species of *Antrophyum*. The only point of similarity is found in the deep soral grooves, which are, however, of little importance in determining the relationship as compared with the venation. In *Vittaria* this consists of a costa and two submarginal veins formed by the interlocking of pinnate branches from the axial vein. In *Antrophyum*, the venation consists of a primary costa, and a secondary system of reticulated veins of uniform size. In the narrow species of *Vittaria*, the pinnate veins are almost indistinguishable, and the venation apparently consists of three primary veins. *Antrophyum lineatum* seems to be in the process of developing a system of several longitudinal veins connected by secondary cross-veinlets, apparently in a manner similar to that in which the narrow species of *Vittaria* have evolved from the broader forms, but related to *Vittaria* only through some ancestral form of both. The process seems to take place by the gradual suppression of the transverse veins, first by a loss of fertility followed by a diminution in size. *A. lanceolatum* represents an earlier stage of the same process. In it the soral lines are mainly on the longitudinal veins, but not to such an extent as in the related species. If they were immersed the resemblance would appear much stronger.

3. ANTROPHYUM LANCEOLATUM (L.) Kaulf. Enum. Fil. 198. 1824.
Hemionitis lanceolata L. Sp. Pl. 1077. 1753. (Type from Jamaica.)
Dictyogramme lanceolata Trev. Atti Ist.Ven. V. 3: 592. 1877.
Antrophyum Féei Schaffner; Fée, Mém. Foug. 7: 42. *pl. 22. f. 1.* 1857. (Type from Mexico.)

Spores triplanate; paraphyses wanting; sporangia in crooked superficial mostly longitudinal lines; fronds linear-lanceolate, 23 × 1–55 × 1.7 cm., usually broadest a little above the middle, sessile, membranous; costas percurrent; margins repand; areolae in rows parallel to the costa, usually pointed.

West Indies and Mexico to northern South America.

This species is one of the commonest and also most easily distinguishable of the genus. Only one other, *A. lineatum*, resembles it closely, and differences in soriation as well as less-marked differences in outline and in the texture of the living plant serve at once to distinguish the two.

In Mexico and Honduras true *A. lanceolatum* is replaced by the form *A. Féei*, which may prove distinct. It has fronds elliptic-lanceolate, 9 × 0.9–19 × 1.4 cm.; smaller and relatively much broader than the type form. Its best claim to recognition lies in the uniform way in which these characters are maintained, combined with its localization in Mexico and Honduras to the exclusion of the related form, which is, however, found not far away in Costa Rica. But if it is a good species, Dominica must be included in its range, since material in the herbarium of the N. Y. Botanical Garden from this island cannot be separated from that collected in Mexico.

4. ANTROPHYUM BRASILIANUM (Desv.) C. Chr. Ind. Fil. 59. 1905.

Hemionitis brasilianum Desv. Prod. 216. 1827. (Type from Brazil.)

Antrophyum subsessile Kunze, Anal. Pter. 29. *pl. 19. f. 1.* 1837. (Type from Peru.)

Antrophyum spathulatum Fée, Mém. Foug. 4: 46. *pl. 4. f. 6.* 1852. (Type from Colombia.)

Spores triplanate; paraphyses wanting; sporangia in simple or branching lines, divergent from near the costa toward the margin: fronds oblanceolate or oblong, 19 × 1.7–30 × 3.5 cm., narrowed very gradually below, subsessile or with margined stipe of indeterminate length, short-acuminate, young fronds acute; epidermis glossy, wrinkled; margins thin and sharp, reflexed; areolae divergent from the costa, rather distinct on the back of frond; marginal areolae closed, small, costa percurrent, prominent below.

BOLIVIA: Isapuri, *Williams 1354;* Tumupasa, *Williams 1353;* San José, *Williams 1352.* BRAZIL: Ilheos, *Martius* (Herb.

Fl. Bras. *369*.) VENEZUELA: Tovar, *Fendler 305* (in part). COSTA RICA: Turrialba, *Maxon 180, 152; Wercklé*. GUATEMALA: Alta Verapaz, *Von Tuerckheim 8059*.

Owing to the uncertainty regarding Desvaux's type, the positive application of this name is at present impossible, but there seems to be little doubt but that it should replace *A. subsessile* Kunze. The two descriptions agree closely and Kunze himself admitted that they might refer to the same plant.*

A. spathulatum Fée is apparently nothing but an abnormally obtuse form which is not very unusual.

5. ANTROPHYUM CAYENNENSE (Desv.) Sprengel, Syst. 4: 67. 1827.

Hemionitis cajennensis Desvaux, Berl. Mag. 5: 311. 1811. (Type from French Guiana.)

Spores triplanate; paraphyses wanting; sporangia in branching, divergent, slightly sunken lines: frond elliptic, acute or acuminate, thin coriaceous, translucent; costa percurrent; margin reflexed; stipes 2–8 cm. long, blades 13 x 2.3–23 x 5 cm.; areolae divergent from the costa, marginal areolae closed, small.

BRITISH GUIANA: 1897, *Jenman*. TRINIDAD: Herb. Bot. Gard. Trin. *346, 1263; Fendler 151*.

The identity of *A. cayennense* is rather doubtful. Desvaux in 1811 described *Hemionitis cajennensis* from French Guiana, but his material was lost sight of and his description would fit either of two species now known from that locality. Kunze, however, arbitrarily applied this name to the form here described. The nomenclature can be definitely settled only by examination of Desvaux's original material.

The species which superficially resembles it most is *A. Jenmani*, from which, however, it differs largely in texture and marginal venation. The herbarium specimens examined had nearly all bleached out to a light color. Those of *A. Jenmani* are all dark-brown. *A. cayennense* has a further distinctive character in its stipe-scales which have much longer setae than any other of the American species.

6. **Antrophyum Dussianum** sp. nov.

Spores triplanate; paraphyses wanting; sporangia in simple or branching slightly sunken lines, divergent from near the costa toward the margin: fronds usually narrowly oblong, 20 × 2–40 × 3.4 cm., tapered gradually both ways, broader a little above the middle, long-acute (young fronds acute), subsessile, membranous, thin, dark-brown when dried; margin flat or slightly reflexed; areolation rather indistinct; areolae divergent from the costa; marginal venation of small closed areolae and some free veinlets; costa superficially distinct to the apex but not prominent.

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* Anal. Pter. 30.

Guadeloupe, *Père Duss 4226* (type). Also Martinique, *Duss 1549;* Dominica, *Lloyd 918;* Trinidad, *Fendler 151 B* (in Eaton herb.); Haïti, *Nash 1358;* Cuba, *Eggers 5269, Wright 775.*

Under this species is included all the West Indian *A. subsessile* so-called except that from Jamaica, which is placed with *A. discoideum.* It resembles *A. lanceolatum*, and seems to form a connection between this plant and the broader species of the genus. It is further distinguished from *A. brasilianum* by its less coriaceous texture and thinner frond, by the presence of rather numerous free veinlets along the margin, and by its less spatulate outline. From *A. discoideum* it is distinguishable by its sunken soral lines; its free veinlets are not punctate at the tips and do not occur regularly as in the latter form.

Two variant forms are included. That from Cuba, *Eggers 5269, Wright 775*, is narrower than the type material, 26 × 2.1–40 × 2.5 cm., and more coriaceous. That from Haïti, *Nash 1358*, is broader and more oblanceolate and acuminate, 25 × 3.5 cm. All three forms are alike in having the stipe-scales very long-attenuate, much more so than in any other American species.

7. **Antrophyum Jenmani** sp. nov.

Sporangia and spores not seen; soral lines apparently as in *A. brasilianum* and the other American species of *Euantrophyum:* fronds broadly elliptic to broadly oblanceolate, 19.5 × 4.5–28 × 7 cm., slightly acuminate, thick, flaccid, friable when dry, opaque; margins slightly reflexed; stipes thick, 2–5 cm. long; costa disappearing near the apex; areolation rather indistinct; areolae narrow, sometimes broad in young fronds, in branching rows which reach at the margin a wide angle of divergence from the costa; marginal areolae open.

BRITISH GUIANA: Potaro River, *Jenman* (type; det. *A. subsessile*); Demerara, Mt. Ragwa, *Jenman* (det. as above). GUIANA: *Leprieur 109* (U. S. Nat. Herb.).

Jenman refers to this plant as large *A. subsessile*,* but it is really one of the most distinct in the group, and it is hard to see how he could confuse it with the small thin form which occurs in Jamaica. It is the largest American species in the genus and is easily recognizable by its open marginal areolae, and its flaccid texture.

8. ANTROPHYUM ANETIOIDES Christ, Bull. Herb. Boiss. II. **5**: 12. 1905. (Type from Costa Rica.)

Spores triplanate; paraphyses wanting; sporangia in simple or branching, more or less connected, superficial lines divergent from the axis; fronds elliptic-lanceolate, 15 × 2.5–18 × 3.5 cm., acute (often blunted), rather thin, flaccid, friable when dry, opaque, sessile; margins very slightly reflexed; costa usually disappearing before the upper third, and scarcely visible even by transmitted light near the apex; areolation rather distinct; areolae divergent at a narrow angle from the axis; marginal areolae open.

COSTA RICA: Las Vueltas, *A. Tonduz 12757*.

Thanks to Dr. Christ's kindness in loaning me authentic material of this species, I have had opportunity to examine it at first hand and to compare it point by point with the related species. It differs from *A. brasilianum*, as he says, in texture and outline. In two other characters it is also easily distinguishable from this species, in its open marginal areolae, and indistinct costa. In its costal characters it is particularly interesting as suggesting a transition between the New and Old World species of this genus. In the species of the latter region, a costa is present usually only in the stipe or lower part of the frond. In the lamina, as a whole, or at least in the upper part, it becomes indistinguishable or can be traced only as a vein no larger than any other in the general network of the leaf. This is practically what happens in *A. anetioides*. The costa is nowhere prominent, and a little above the middle of the frond it can be distinguished only by transmitted light, while towards the apex it becomes no larger than the lateral veins.

9. ANTROPHYUM DISCOIDEUM Kunze, Bot. Zeit. **6**: 702. 1848. (Type from Colombia, *Karsten*.)

Spores triplanate; paraphyses wanting; sporangia in simple wavy or branching superficial lines, sometimes considerably connected, divergent from near the costa toward the margin; fronds elongate-oblong, 26 × 4 cm., 35 × 4 cm., 39 × 3.4 cm., narrowed very gradually below to a subsessile base, less gradually above to an acute apex (young fronds rounded or obtuse), membranous, firm; epidermis smooth and dull; margins flat, thin, slightly repand; areolation rather distinct; areolae divergent from the costa; marginal areolae open, ends of free veinlets enlarged and usually darkened; costa disappearing toward the apex, and visible only by transmitted light.

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* Bull. Dept. Bot. Jam. II. 4: 211. 1897.

Colombia and Venezuela to Bolivia; Jamaica (?). Alt. 1800–2300 meters.

BOLIVIA: Santa Barbara, *Williams 1355*. VENEZUELA: Manoa, Lower Orinoco, *Rusby & Squires 371*; without definite locality, *Fendler 305*, in part (Eaton Herbarium).

Kunze's description is as follows: *A. fronde lineari-lanceolata, ensiformi-curvata, acuminata, bas longe attenuata in stipitem decurrente, tenuiter marginata, costata; venis obscuris, areolis erectis; soris immersis, flexuosis, interruptis, nec basin, nec apicem, nec marginem attingentibus.*

It will be seen that the two descriptions differ in two characters, outline and soriation. Kunze has "*lineari-lanceolata*" as compared with my "elongate-oblong," and "*soris immersis*" instead of "superficial." The difficulty regarding the first point is removed by a further reference to the form in his discussion of the species. He speaks of it as less spatulate than *A. brasilianum.* This would make it correspond to the description given here. In the other case, it is probable that the facts were misinterpreted. Soral lines which are not at all immersed, may appear so because of a blackening of the line of attachment. But, whatever the name eventually adopted for this species, it is distinct from *A. brasilianum*, with which it has always been confused.

The best distinctive character is found in the marginal venation, which in this species consists of free veinlets, the ends of which are thickened and usually blackened or brown. In good material these ends appear as a line of dots around the leaf about one and a half millimeters inside the thin margin. The dull smooth surface and the very thin tissue also serve to differentiate it from *A. brasilianum*, which has a wrinkled and rather glossy surface, and a thicker leaf.

The material of *A. subsessile* so-called from Jamaica seems to belong here, but its form is not typical. It is much shorter and usually more oblanceolate and less acute, but it shows to a marked degree the line of dots along the ends of the veinlets. The range in size is shown by the following specimens:

Underwood 1370. 21.5 × 2.5 cm.
Jenman, coll. in 1876. 18 × 3 cm.

Species inquirenda

ANTROPHYUM DESVAUXII Moore, Ind. Fil. 80. 1858.
Hemionitis gigantea Desv. Prodr. 216. 1827. (Type from St. Thomas, West Indies.)

Frondibus ecostatis, late lanceolatis, acutis, basi in stipitem late compressum dilatatis; lineolis dense reticulatis superficialibus. Habitat in insula Sancti-Thomae Antillarum. 2 ped. et ultra; 4 poll. lata. (Desvaux.)

The description agrees with that of Bory's *Antrophyum giganteum*, from the Mascarene Islands. The characters and dimensions given fit that species exactly. The following quotation from De Candolle's "Phytographie" may throw some light on the confusion. Speaking of Desvaux's herbarium, the writer says (page 408), "*Les omissions ou indications fausses de pays et la similitude de certains échantillons avec ceux du Muséum rendent cet herbier fort curieux.*" As the species under consideration could not possibly have come from the locality cited, the conclusions are obvious. The only possible explanation creditable to Desvaux, is that his material came from the African island, St. Thomas, which lies off the west coast, but this presupposes an improbable distribution for the fern, to say the least, and the accidental confusing of the two continents is not very likely.

Species excludenda

ANTROPHYUM MINIMUM Baker, Ann. Bot. 5:488. 1891. (Type from Costa Rica.) = **Hecistopteris minima** (Baker).

Soon after I began to study this species, I came to the conclusion that it belonged with *Vittaria* because of (1) the diplanate spores and the peculiarly shaped paraphyses, which are identical in form and size with those of *Vittaria costata* Kunze, (2) the venation, which is that of a very young leaf of *Vittaria lineata* as figured in a paper on the life-history of that species by E. G. Britton and A. Taylor.* But further study showed me that it was certainly congeneric with *Hecistopteris pumila* (Spr.) J. Smith, which possesses similar paraphyses and spores, and, as shown by Goebel, † has a vittarioid prothallium. The only distinction, except in form, is found in the venation, free-forking in *H. pumila*, and pinnate-anastomosing in *H. minima*. Dr. Christ has described another species, *H. Werckleana* ‡ (*Antrophyum Werckleanum* §), which seems to be intermediate in form between the other two, and may show a transitional type of venation. In the material of *H. minima* examined (*Endres*), one frond was found showing a forked tip. The sori are not sunken as stated by Baker in his description, but entirely superficial and in other respects like those of *H. pumila*. Taken together, the three species form a very natural genus with affinities close to *Vittaria*.

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* Mem. Torrey Club 8: 158–211. *pl. 23–31.* 1902.

† Flora 82: 67. 1896.

‡ Bull. Bois. II. 7: 265. 1907.

§ Bull. Bois. II. 5: 11. 1905.

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Vol. 22, part 2, issued December 18, 1905, contains descriptions of the families Saxifragaceae and Hydrangeaceae by Dr. J. K. Small and Dr. P. A. Rydberg; the Cunoniaceae, Iteaceae and Hamamelidaceae by Dr. N. L. Britton; the Pterostemonaceae by Dr. J. K. Small; the Altingiaceae by Percy Wilson and the Phyllonomaceae by Dr. H. H. Rusby.

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Vol. 7, part 2, issued March 6, 1907, contains descriptions of the families Coleosporiaceae, Uredinaceae and Aecidiaceae (pars), by Professor J. C. Arthur.

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SOME PHILIPPINE POLYPORACEAE

By WILLIAM ALPHONSO MURRILL

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Some Philippine Polyporaceae

WILLIAM ALPHONSO MURRILL

A large number of Philippine polypores have been added to the herbarium of the New York Botanical Garden during the last few years, mainly through the efforts of Mr. Robert S. Williams, who was collecting in the islands from November, 1903 to July, 1905, and to some extent from the collections of Mr. Elmer D. Merrill and Mr. A. D. E. Elmer, who sent material either to Mr. Ricker or myself for determination. A list of these additions to the herbarium is given in the following pages.

Mr. Williams collected the most of his specimens on the Lamao River and elsewhere on the slopes of Mt. Mariveles across the bay west of Manila. At Baguio, some distance to the north, he reached an elevation of 5200 feet, about 1000 feet higher than Mt. Mariveles, and found open pine woods, with much dead pine timber left by lumbermen. At Santa Cruz, on the Gulf of Davao, in Mindanao, he collected at an elevation of only a few hundred feet, and mostly in a more continuous forest than in the Lamao region. The specimens from Mr. Merrill and Mr. Elmer were collected in Luzon, Mindanao, Mindoro, Palawan, Culion, and Leyte.

A number of Philippine species which have been seen in European herbaria have as yet failed to appear in these additions, but it is hoped that the list will be complete enough in a year or two more so that a fairly full synopsis of Philippine polypores will be possible. Excursions into the interior of the larger islands will undoubtedly bring to light a considerable number of novelties, while further explorations among the smaller islands will serve more strongly to connect the native species with their relatives in Formosa, China, Japan, Malacca, Borneo, Java, Celebes, New Guinea, Australia, and the many small neighboring islands of the Pacific.

Subfamily POLYPOREAE

COLTRICIA CINNAMOMEA (Jacq.) Murrill, Bull. Torrey Club **31**: 343. 1904.

Luzon: Mt. Mariveles, *Elmer 6949*.

COLTRICIA PERENNIS (L.) Murrill, Jour. Myc. 9 : 91. 1903.
Luzon : Baguio, *Williams.*

Coriolopsis aneba (Berk.) Murrill. *Polyporus anebus* Berk. Lond. Jour. Bot. 6: 504. 1847. (Type from Ceylon.) *? Polyporus bicolor* Jungh. Fl. Crypt. Jav. 1 : [54]. 1838. (Type from Java.)
Luzon : Mt. Mariveles, *Elmer 6909.*

Coriolopsis badia (Berk.) Murrill. *Trametes badia* Berk. Lond. Jour. Bot. 1 : 151. 1842. (Type from the Philippines.) *Polystictus badius* Cooke, Grevillea 14 : 86. 1886.
Luzon : Lamao, 70 m., 115 m., 130 m., *Williams.* Culion : *Merrill 3526.* Mindanao : Santa Cruz, Gulf of Davao, *Williams.*

Coriolopsis dermatodes (Lév.) Murrill. *Trametes dermatodes* Lév. Ann. Sci. Nat. Bot. III. 2 : 196. 1844. *? Polyporus cervino-gilvus* Jungh. Fl. Crypt. Jav. 1 : [45]. *pl. 9.* 1838. (Type from Java.) *Polyporus dermatodes* Lév.; Gaud. Voy. Bonite 1 : 180. *pl. 138. f. 2.* 1846. *Polyporus Peradeniae* Berk. & Br. Jour. Linn. Soc. Bot. 14 : 51. 1885. (Type from Ceylon.)
Luzon : Lamao, 70 m., 80 m., 115 m., 130 m., *Williams ;* Mt. Mariveles, *Elmer 6936, 6957.*

CORIOLOPSIS OCCIDENTALIS (Kl.) Murrill, Bull. Torrey Club 32 : 358. 1905. *Polyporus lanatus* Fr. Epicr. 490. 1838. (Type from the East Indies.) *Polyporus scorteus* Fr. Nov. Symb. 89. 1851. (Type from Pulo-Milu.)
Luzon : Lamao, 15 m., *Williams.* Culion : *Merrill 3571.* Mindanao : Santa Cruz, Gulf of Davao, *Williams.*

Coriolopsis phocinus (Berk. & Br.) Murrill. *Polyporus phocinus* Berk. & Br. Jour. Linn. Soc. Bot. 14 : 52. 1885. (Type from Ceylon.)
Luzon : Lamao, 80 m., *Williams.*

Coriolopsis semilaccata (Berk.) Murrill. *Polyporus zonalis semilaccatus* Berk. Jour. Linn. Soc. Bot. 16 : 46. 1878. (Type from Malamon.) *Fomes semilaccatus* (Berk.) Cooke, Grevillea 15 : 22. 1886.
Luzon : Bataan, *Merrill 3503 ;* Mt. Mariveles, *Elmer 6929, 6946 ;* Mt. Banahao, *Elmer 7557.*

CORIOLUS ABIETINUS (Dicks.) Quél. Ench. Fung. 175. 1886.

Luzon: Baguio, *Williams.*

CORIOLUS ATYPUS (Lév.) Pat. Tax. Hymén. 94. 1900. *Polyporus atypus* Lév. Ann. Sci. Nat. Bot. III. 2: 184. 1844. (Type from Java.) *? Polyporus brunneolus* Berk. Lond. Jour. Bot. 3: 187. 1844. (Type from the Philippines.) *? Polystictus Didrichsenii* Fr. Nov. Symb. 76. 1851. (Type from the island of Bora-bora.) *Trametes Aurora* Ces. Myc. Borneo 5. 1897. (Type from Borneo.)

Luzon: Lamao, 75 m., 80 m., 115 m., 500 m., *Williams;* Mt. Mariveles, *Merrill 3506, Elmer 6938, 6940, 6947, 6955, 6958;* Bataan, *Merrill 3505.* Mindoro: Baco River, *Merrill 3578.*

Coriolus cuneatiformis Murrill, sp. nov.

Pileus flabelliform, with a cuneate base, thin, dry, flexible, conchate, depressed behind, 2–3 × 3–4 × 0.1 cm.; surface subglabrous, zonate, smooth, white, with pale-avellaneous zones, sometimes avellaneous behind; margin very thin, entire, slightly deflexed when dry: context thin, white, fibrous, less than 1 mm. thick; tubes short, yellowish-white, 1 mm. long, mouths minute, circular to angular, regular, 6 to a mm., edges thin, entire, white to pale-yellowish: spores ellipsoidal, smooth, hyaline, 2.5–3 × 5–6 μ; hyphae hyaline, 3.5–5 μ; cystidia none.

Type collected on the Lamao River, Luzon, 80 m., on dead wood, December 1903, by R. S. Williams.

CORIOLUS ELONGATUS (Berk.) Pat. Tax. Hymén. 94. 1900. *Polyporus elongatus* Berk. Lond. Jour. Bot. 1: 149. 1842. (Type from the Philippines.)

Luzon: Lamao, 500 m., 700 m., *Williams.*

Coriolus maximus (Mont.) Murrill. *Irpex maximus* Mont. Ann. Sci. Nat. II. 8: 364. 1837. (Type from Cuba.) *Polyporus Meyenii* Kl. Nov. Act. Acad. Nat. Cur. 19: Suppl. 236. 1843. (Type from Manila.)

Luzon: Lamao, 80 m., 115 m., *Williams;* Mt. Mariveles, *Elmer 6931;* Bataan, *Merrill 3499.*

Coriolus murinus (Lév.) Pat. Tax. Hymén. 94. 1900. *Polyporus murinus* Lév. Ann. Sci. Nat. Bot. III. 2: 185. 1844. (Type from Java.)

Luzon: Lamao, 115 m., 130 m., *Williams.* Leyte: Palo, *Elmer 7237.*

Coriolus vernicipes (Berk.) Murrill. *Polyporus vernicipes* Berk. Jour. Linn. Soc. Bot. **16**: 50. 1878. (Type from Japan.)

Luzon: Mt. Banahao, 650 m., *Elmer 7550*.

Cycloporellus* **cichoriaceus** (Fr.) Murrill. *Polyporus intybaceus* Berk. Lond. Jour. Bot. **1**: 149. 1842. (Type from the Philippines.) Not *P. intybaceus* Fr. *Polystictus cichoriaceus* Fr. Nov. Act. Reg. Soc. Sci. Ups. III. **1**: 92. 1855. *Polyporus setiporus* Berk. Hook. Lond. Jour. Bot. **6**: 505. *pl. 20. f. 2.* 1847. (Type from Ceylon.)

Luzon: Upper Lamao, 700 m., *Williams;* Lamao, *Merrill 3528*.

Cycloporellus microcyclus (Lév.) Murrill. *Polyporus microcyclus* Lév. Ann. Sci. Nat. Bot. III. **2**: 188. 1844. (Type from Java.)

Luzon: Lamao, 115 m., *Williams;* Upper Lamao, 700 m., *Williams;* Mt. Mariveles, *Elmer 6937*. Leyte: Palo, *Elmer 7228*.

Earliella corrugata (Pers.) Murrill. *Polyporus corrugatus* Pers.; Gaud. Voy. Freyc. Bot. 172. 1826. *Polyporus fusco-badius* Pers.; Gaud. Voy. Freyc. Bot. 172. 1826. (Type from the Marianne Islands.) *Polyporus scabrosus* Pers.; Gaud. Voy. Freyc. Bot. 172. 1826. (Type from the Marianne Islands.) *? Polyporus mariannus* Pers.; Gaud. Voy. Freyc. Bot. 173. 1826. (Type from the Marianne Islands.) *Daedalea sanguinea* Kl. Linnaea **8**: 481. 1833. (Type from the East Indies.) *? Trametes bicolor* Berk. Trans. Linn. Soc. Bot. **16**: 43. 1878. (Type from the island of Aru.) *Polystictus Persoonii* Cooke, Grevillea **14**: 85. 1886. *Trametes nitida* Pat. Jour. de Bot. **4**: 17. 1890. (Type from Tonkin.)

Luzon: Mt. Mariveles, *Elmer 6921, 6935*. Leyte: Palo, *Elmer 7206, 7208*.

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* The genus *Cyclomycetella* (Bull. Torrey Club **31**: 422. 1904), based on *Boletus pavonius* Hook., becomes a synonym of *Coriolus*, since the real type of this species proves to be a member of the latter genus, rather than synonymous with *Polyporus iodinus* Mont. as generally supposed. I therefore suggest the name **Cycloporellus** for this group of species, with *Polyporus iodinus* Mont. (Ann. Sci. Nat. Bot. II. **16**: 108. 1841) as its type, and with the same diagnosis as that already published for *Cyclomycetella*.

FAVOLUS TENUIS (Hook.) Murrill, **Bull.** Torrey Club **32**: 100. 1905. *Polyporus bivalvis* Pers.; Gaud. Voy. Freyc. 168. 1826. (Type from Rawak.) *Hexagona orbiculata* Fr. Fung. Guin. *f. 9.* 1837. (Type from Guinea.) *Hexagona cervino-plumbea* Jungh. Crypt. Java 61. *f. 32.* 1838. (Type from Java.) *Hexagona Thwaitesii* B. & C. Proc. Am. Acad. Arts & Sci. **4**: 122. 1860. (Type from Bonin island.)

Luzon: Lamao, 70 m., 130 m., *Williams;* Mt. Mariveles, *Elmer 6927, 6934.* Leyte: Palo, *Elmer 7226.*

FAVOLUS WIGHTII (Kl.) Ricker, Philipp. Jour. Sci. **1**: Suppl. 286. 1906. *Polyporus Wightii* Kl. Linnaea **7**: 200. *pl. 10.* 1832. *Hexagona Wightii* Fr. Epicr. 496. 1838.

Pileus thin, coriaceous, flexible, umbonate-affixed, dimidiate to reniform, applanate when young, becoming deeply depressed with age, 5–10 × 7–16 × 0.2 cm., surface multizonate, marked with a few concentric ridges, pale-umbrinous and nearly glabrous when young, then chestnut-colored, with a few appressed aculeae, and finally opaque-black and clothed with conspicuous, erect or ascending, rigid, flattened, somewhat branched, black aculeae; margin very thin, isabelline, undulate or slightly lobed: context scarcely 1 mm. thick, tough, punky, fibrous; tubes 1.5 mm. long, cinereous or fulvous and glabrous within, mouths large, shallow, equally hexagonal, 1–3 mm. in diameter, cinereous or fulvous, edges thin, rarely obtuse, firm, entire.

Luzon: Mt. Mariveles, *Elmer 6913, 6919;* Lamao, 130 m., *Williams.*

Funalia philippinensis Murrill, sp. nov.

Pileus sessile, dimidiate, subimbricate, applanate above, slightly convex below, 5–10 × 10–15 × 1–2 cm.; surface slightly zonate near the margin, dark-fulvous throughout, very conspicuously clothed with rigid, branched, flattened or terete, concolorous, pointed aculeae, which partially disappear in extreme age; margin ochraceous, sterile, acute, undulate: context ferruginous, thin, punky-corky, 2–3 mm. thick; tubes 5–10 mm. long, ferruginous-fulvous within, mouths circular to hexagonal, very regular, averaging 1 mm. in diameter, edges thin, firm, entire, white when young, becoming dark-umbrinous: spores ovoid, smooth, hyaline, 3.5–4.5 μ; hyphae pale-ferruginous, 2–4 μ; cystidia none.

Type collected on the Lamao River, Luzon, 115 m., on dead wood, February, 1904, by R. S. Williams.

Funalia versatilis (Berk.) Murrill. *Trametes versatilis* Berk.

Lond. Jour. Bot. **1**: 150. 1842. (Type from the Philippines.) *Hexagonia ciliata* Kl. Nov. Act. Acad. Nat. Cur. **19**: Suppl. 235. *pl. 5. f. 1.* 1843. *Polystictus cilicioides* Fr. Nov. Symb. 87. 1851.

Luzon: Lamao, 80 m., 115 m., *Williams.* Mindanao: Santa Cruz, Gulf of Davao, *Williams.*

HAPALOPILUS GILVUS (Schw.) Murrill, Bull. Torrey Club **31**: 418. 1904. *Polyporus discipes* Berk. Hook., Lond. Jour. Bot. **6**: 499. 1847. (Type from Ceylon.) *Polyporus holosclerus* Berk. Lond. Jour. Bot. **6**: 501. 1847. (Type from Ceylon.) *Polyporus spadiceus* Berk. Ann. Mag. Nat. Hist. **3**: 388. 1839. (Type from the East Indies.) *Polyporus breviporus* Cooke, Grevillea **12**: 17. 1883. (Type from Australia.) *Polyporus aureomarginatus* P. Henn. Bot. Jahrb. **22**: 72. 1895. (Type from Kamerun.)

Luzon: Lamao, 70 m., 130 m., *Williams;* Lamao, *Merrill 3525;* Mt. Mariveles, *Elmer 6925.*

HAPALOPILUS LICNOIDES (Mont.) Murrill, Bull. Torrey Club **31**: 417. 1904.

Culion: *Merrill 3607.*

Hapalopilus subrubidus Murrill, sp. nov.

Pileus imbricate, umbonate-sessile or attached by a narrow base, dimidiate or flabelliform, conchate, thin, slightly flexible, 3–4 × 4–6 × 0.1–0.3 cm.; surface glabrous, slightly zonate, fulvous; margin thin, straight, entire or slightly undulate, reddish-brown when bruised: context ferruginous, punky-fibrous, tough, 1–2 mm. thick; tubes short, dark-lilac within, 1 mm. in length, mouths minute, slightly angular, regular, 7–8 to a mm., edges thin, entire, dark flesh-colored to fulvous: spores globose, smooth, hyaline, 3–4 μ; hyphae 2–3 μ, pale-ferruginous; cystidia none.

Type collected on Mt. Mariveles, Luzon, on dead wood, November, 1904, by A. D. E. Elmer, *no. 6912.*

HEXAGONA CUCULLATA (Mont.) Murrill, Bull. Torrey Club **31**: 332. 1904.

Mindanao: Santa Cruz, Gulf of Davao, *Williams.*

Hexagona vibecinoides (P. Henn.) Murrill. *Polyporus vibecinoides* P. Henn. Bot. Jahrb. **23**: 546. 1896. (Type from Kamerun, Africa.)

Luzon: Lamao, 70 m., *Williams.*

Inonotus Elmerianus Murrill, sp. nov.

Pileus subimbricate, sessile, dimidiate, conchate, thin, slightly flexible, 3×4–5×0.1–0.3 cm.; surface finely tomentose to nearly glabrous, spongy-tomentose behind or in certain parts, very uneven, slightly zonate, ferruginous to fulvous, fuliginous at times behind; margin thin, undulate, ferruginous: context ferruginous, punky above, fibrous below, 1 mm. or less thick; tubes short, fulvous within, 0.5–1.5 mm. long, mouths very minute, regular, circular to angular, 9–11 to a mm., fulvous to umbrinous, bay when bruised, stuffed with flavous to luteous mycelium when very young, edges thin, entire: spores subglobose, smooth, pale-ferruginous, copious, 2 μ; hyphae pale-ferruginous, 3–4 μ; cystidia none.

Type collected on Mt. Mariveles, Luzon, on dead wood, November, 1904, by A. D. E. Elmer, *no. 6942.*

Microporellus subdealbatus Murrill, sp. nov.

Pileus very thin, tough, flexible, flabelliform, tapering to a short flattened stipe, which appears to be merely a continuation of the pileus, 4 × 3 × 0.1 cm.; surface zonate, fibrillose to glabrous, resinous in appearance, pale-yellowish or light reddish-brown; margin very thin, sterile, lacerate, uneven: context very thin, white, fibrous, flexible; tubes short, decurrent, white within, mouths small, glistening, irregular, angular, white to slightly yellowish, 5 to a mm., edges acute, uneven, lacerate-dentate, soon becoming irpiciform: spores ovoid, smooth, hyaline, 3–4 μ; hyphae hyaline, 3–4 μ; cystidia none.

Type collected in the Province of Bataan, Luzon, on prostrate logs, October, 1903, by E. D. Merrill, *no. 3511.*

Nigroporus durus (Jungh.) Murrill. *Polyporus durus* Jungh. Fl. Crypt. Jav. **1**: [62]. 1838. (Type from Java.)

Luzon: Bataan, *Merrill 3500.*

NIGROPORUS VINOSUS Murrill, Bull. Torrey Club **32**: 361. 1905. (Type from San Domingo.)

Luzon: Lamao, 70 m., *Williams.* Leyte: Palo, *Elmer 7212.*

POLYPORUS CELEBICUS P. Henn. Monsunia **1**: 12. *pl. 1. f. 5.* 1899. (Type from Celebes.)

Luzon: Lamao, 75 m., 80 m., 130 m., *Williams.*

Polyporus coracinus Murrill, sp. nov.

Pileus suborbicular to reniform, attached by a short lateral tubercle, thin, fleshy-tough, conchate, 3–4 × 4–5 × 0.2 cm., surface yellowish-white, finely tomentose, becoming glabrous and black;

margin thin, entire, concolorous: context less than 1 mm. thick, homogeneous and white to pallid, except the very thin black cuticle; tubes 1.5 mm. long, white to avellaneous within, mouths circular, regular, 4 to a mm., pallid to black, edges very obtuse, entire: spores subglobose, smooth, hyaline, 2.5–3.5 μ; hyphae 3 μ; cystidia dark-fulvous, short, ventricose, sharp-pointed, 10–25 μ, often branched or cespitose.

Type collected at Palo, Leyte, on dead sticks, January, 1906, by A. D. E. Elmer, *no. 7232.*

POLYPORUS GRAMMOCEPHALUS Berk. Lond. Jour. Bot. **1**: 148. 1842. (Type from the Philippines.)

Mindanao: Santa Cruz, Gulf of Davao, *Williams.*

Polyporus palensis Murrill, sp. nov.

Pileus flabelliform, tapering behind, shallowly depressed to infundibuliform, 2–3 × 2–3 × 0.1 cm.; surface white to fulvous, finely radiate-striate, glabrous; margin very thin, entire to undulate or lacerate, inflexed on drying: context very thin, fleshy, white, fragile when dry; tubes decurrent, less than 1 mm. long, white or slightly flesh-colored within, mouths minute, white to dull-fulvous, fragile when dry, somewhat radially elongated, 0.5 × 0.25 mm., edges lacerate-dentate, becoming almost irpiciform in appearance: spores oblong-ellipsoid, smooth, hyaline, 3–4 × 5–6 μ; hyphae smooth, hyaline, 3–4 μ; cystidia none: stipe lateral, rarely eccentric, short, tapering below, white, terete, striate above, covered with tubes below at the base, 3 mm. long, 2 mm. thick.

Type collected at Palo, Leyte, on dead sticks, January, 1906, by A. D. E. Elmer, *no. 7236.*

POLYPORUS PERULA (Beauv.) Fr. Epicr. 437. 1838. *Microporus Perula* Beauv. Fl. Owar. **1**: 12. *pl. 43.* 1805. (Type from Wari.) *Polyporus xanthopus* Fr. Obs. Myc. **2**: 255. 1818. (Type locality unknown.) *Polyporus affinis* Nees, Nov. Act. Acad. Nat. Cur. **13**^{1}: *pl. 4. f. 1.* 1826. *Polyporus incomptus* Fr. Epicr. 437. 1838. (Type from Guinea.) *Polyporus polychrous* Ces. Myc. Borneo 4. 1879. (Type from Borneo.) *Polyporus carneo-niger* Berk.; Cooke, Grevillea **12**: 15. 1883. (Type from Australia.)

Luzon: Baguio, *Williams;* Bataan, *Merrill 3498, 3502, 3535;* Mt. Banahao, *Elmer, 7546, 7552, 7555;* Lamao, 70 m., 80 m., 100 m., 115 m., 700 m., *Williams;* Mt. Mariveles, *Elmer 6908, 6920, 6923, 6926, Merrill 3495.* Mindanao:

Santa Cruz, Gulf of Davao, *Williams.* Mindoro: Baco River, *Merrill 3582.* Palawan: Ewiig River, *Merrill 3585, 3588.* Culion: *Merrill 3605.*

POLYPORUS VIBECINUS Fr. Kongl. Vet.-Akad. Handl. Stockh. 126. 1849. (Type from Natal.)

Luzon: Lamao, 80 m., *Williams.*

PYCNOPORUS SANGUINEUS (L.) Murrill, Bull. Torrey Club **31**: 421. 1904.

Luzon: Lamao, 75 m. and 130 m., *Williams;* Province of Tarlac, *Merrill 3601.* Leyte: Palo, *Elmer 7239.* Mindanao: Santa Cruz, Gulf of Davao, *Williams.*

Rigidoporus surinamensis (Miq.) Murrill. *Polyporus surinamensis* Miq. Bull. Sci. Phys. Nat. Néerl. **1839**: 454. 1839. *Polyporus zonalis* Berk. Ann. Mag. Nat. Hist. **10**: Suppl. 375. *pl. 10. f. 5.* 1843. (Type from Ceylon.)

Luzon: Mt. Banahao, 900 m., *Elmer 7549.*

Spongipellis luzonensis Murrill, sp. nov.

Pileus thin, tough, rigid, imbricate, laterally connate, sessile, dimidiate, somewhat decurrent, conchate, 1–1.5 × 1.5–2.5 × 0.2–0.5 cm.; surface azonate, anoderm, fibrillose-tomentose, white to discolored, absorbing water; margin thin, undulate, concolorous, easily bruised, fertile, decurved when dry: context spongy-fibrous, white to pale-isabelline, about 2 mm. thick, tubes white to discolored, tough, elastic, 2–3 mm. long, mouths white to discolored, irregular, 4–6 to a mm., subglistening, edges very thin, fimbriate-dentate: spores globose, smooth, hyaline, 3–4 μ; hyphae hyaline, 5–6 μ; cystidia none.

Type collected on Mt. Mariveles, Luzon, on dead wood, November, 1904, by A. D. E. Elmer, *no. 6944.*

Trametes caespitosa Murrill, sp. nov.

Hymenophore densely imbricate, dimidiate, conchate, laterally connate, 1–2 × 2–3.5 × 0.2–0.3 cm.; surface puberulent to subglabrous, smooth, very slightly subzonate, pale-avellaneous, with a tinge of pale-purple; margin rather thick, concolorous, undulate, sharply deflexed: context white, fibrous, rigid, tough, 1–2 mm. thick; tubes white to pallid, 1–1.5 mm. long, mouths very regular, minute, circular, white to pallid, with a tinge of flesh color, 7–8 to a mm., edges rather thick, firm, tough, entire: spores smooth, hyaline, ovoid, copious, 5–6 × 7–7.5 μ; hyphae hyaline, 5–6 μ; cystidia none.

Type collected on Mt. Mariveles, Luzon, on dead wood, November, 1904, by A. D. E. Elmer, *no. 6951.*

Trametes lamaensis Murrill, sp. nov.

Pileus subcircular, narrowly attached, convex above and below, 3–4 × 3–4 × 1 cm.; surface finely puberulent, anoderm, slightly zonate or sulcate at times, white or pale-isabelline; margin rather thick, sterile, concolorous, entire: context white, subzonate, punky-corky, 7 mm. thick; tubes firm, tough, pallid, 2–3 mm. long, mouths somewhat irregular, circular to angular, 2–3 to a mm., subglistening, white to isabelline, edges rather thick, entire: spores globose, smooth, hyaline, 5–6 μ; hyphae hyaline, 4–5 μ; cystidia none.

Type collected on the Lamao River, Luzon, 130 m., on dead deciduous wood, February, 1904, by R. S. Williams.

Trametes luzonensis Murrill, sp. nov.

Pileus small, laterally connate, dimidiate, sessile, rarely encircling the twig, conchate, 1–2 × 1.5–3 × 0.2–0.4 cm.; surface smooth, anoderm, finely tomentose to subglabrous, white to very pale avellaneous, entirely without marks; margin acute, entire, deflexed when dry: context punky, white, 1–2 mm. thick; tubes white within, 1–2 mm. long, tough, mouths regular, minute, circular, 6 to a mm., edges white to slightly discolored, rather thick, entire: spores smooth, hyaline.

Type collected on Mt. Mariveles, Luzon, on dead sticks, November, 1904, by A. D. E. Elmer, *no. 6932.*

TRAMETES MÜLLERI Berk. Jour. Linn. Soc. Bot. **10**: 320. 1868. (Type from Victoria River, Australia.)

Luzon: Province of Tarlac, *Merrill 3602.*

Trametes ostreaeformis (Berk.) Murrill. *Polyporus ostreaeformis* Berk. Jour. Linn. Soc. Bot. **16**: 46. 1878. (Type from the Philippines.)

Luzon: Lamao, 600 m., *Williams.*

Trametes subacuta Murrill, sp. nov.

Pileus very large, dry, firm, slightly flexible, reniform, sessile, applanate, 10–12 × 20 × 1–2 cm.; surface narrowly zonate, finely puberulent, becoming glabrous and tuberculose behind, avellaneous or umbrinous in front, murinous behind; margin ochraceous, thin, entire, fertile: context punky-corky, rather soft, white, 5–7 mm. thick; tubes 5 mm. long, white to pallid within, firm, tough, mouths glistening, very regular, circular, 2–3 to a mm., white to pale-isabelline, edges rather thin, entire: spores subglobose to ovoid, smooth, hyaline, 4–5 μ long, hyphae hyaline, 3–5 μ; cystidia none.

Type collected on the Lamao River, Luzon, 115 m., on dead deciduous wood, December, 1903, by R. S. Williams.

Trametes Williamsii Murrill, sp. nov.

Pileus sessile, dimidiate, subimbricate, at times laterally connate, applanate, thicker behind, 4–5 × 4–7 × 1 cm.; surface finely tomentose to nearly glabrous, slightly zonate, isabelline or avellaneous, sometimes partly murinous, anoderm, slightly tuberculose; margin thick, sterile, entire, easily bruised: context corky, tough, somewhat zonate, white, 5–7 mm. thick, eagerly devoured by insects; tubes pallid, 5 mm. long, tough, firm, mouths circular, regular, pallid, 2–3 to a mm., edges thick, obtuse, entire: spores globose, smooth, hyaline, 4–5 μ; hyphae hyaline, 3–4 μ; cystidia none.

Type collected at Santa Cruz, Gulf of Davao, Mindanao, on dead pine logs, June, 1905, by R. S. Williams.

Tyromyces Elmeri Murrill, sp. nov.

Pileus fleshy, rigid and fragile when dry, dimidiate, sessile, subimbricate, 2–3 × 3–4 × 0.2–0.3 cm.; surface rough, with minute tubercles and pits, glabrous, white to isabelline; margin rather thick, entire, concolorous: context white, fleshy-tough, 1 mm. thick; tubes white to isabelline within, 2 mm. long, mouths slightly angular, minute, regular, 6–7 to a mm., pruinose, glistening, at length avellaneous, edges thin, entire: spores globose, smooth, hyaline, 3–4 μ; hyphae hyaline, 4–5 μ; cystidia none.

Type collected on Mt. Mariveles, Luzon, on dead wood, November, 1904, by A. D. E. Elmer, *no. 6954*.

Subfamily FOMITEAE

Amauroderma Elmerianum Murrill, sp. nov.

Pileus stipitate, umbonate-affixed, subcircular to reniform, usually convex above, plane or slightly concave below, hard and rigid, 3 × 4–7 × 0.5–1 cm.; surface thinly encrusted, finely puberulent, conspicuously radiate-rugose, many times sulcate, marked with narrow, avellaneous lines and broad, fuliginous or black zones; margin thick, truncate, zonate, crumpled or rugose, concolorous: context avellaneous, punky-corky, homogeneous, 2–4 mm. thick; tubes 3–7 mm. long, slender, avellaneous within, mouths regular, circular, constricted, 5–6 to a mm., nearly white to smoky-black, reddish-brown when bruised, edges thick, obtuse, entire: spores subglobose, very pale brown, finely echinulate, thick-walled, 5–6 μ; hyphae subhyaline, 3–5 μ; cystidia none: stipe laterally-attached, ascending, cylindrical, subequal, 3–12 cm. long, 0.7–1.3 cm. thick, resembling the pileus in surface and substance.

Type collected at Palo, Leyte, on dead stumps, January, 1906, by A. D. E. Elmer, *no. 7210*. Also collected on Mt. Mariveles, Luzon, November, 1904, by Elmer, *no. 6960*.

Elfvingia Elmeri Murrill, sp. nov.

Pileus very large, compressed-ungulate, convex above, slightly concave below, sessile, dimidiate, very hard, 20 × 25–35 × 4–7 cm.; surface glabrous, deeply sulcate, tuberculose, horny-encrusted, becoming slightly rimose when old and dry, but never weathering, brown with a grayish tinge; margin thick, rounded, ferruginous, entire: context ferruginous to fulvous, punky-corky, rather firm, 1–2 cm. thick; tubes distinctly stratified, 1–2 mm. long each season, fulvous within, mouths circular, regular, 5 to a mm., edges rather thin, entire: spores ferruginous, globose, smooth, 5–6 μ; hyphae ferruginous, 3–4 μ; cystidia ventricose, fulvous, sharp-pointed, copious, 15–40 μ long.

Type collected on Mt. Mariveles, Luzon, on dead wood, November, 1904, by A. D. E. Elmer, *no. 6961*.

ELFVINGIA TORNATA (Pers.) Murrill, Bull. Torrey Club **30**: 301. 1903. *Polyporus tornatus* Pers.; Gaud. Voy. Freyc. Bot. 173. 1826. (Type from islands in the Pacific ocean.) *Polyporus australis* Fr. Elench. 108. 1828. (Type from islands in the Pacific ocean.)

Luzon: Mt. Mariveles, *Elmer 6916*. Culion: *Merrill 3572*. Leyte: Palo, *Elmer 7209*.

Fomes luzonensis Murrill, sp. nov.

Pileus dimidiate, umbonate-affixed, compressed-ungulate, very convex above, plane or slightly concave below, 4 × 6–8 × 1–2 cm.; surface zonate, sulcate, glabrous, horny-encrusted, dull-brown in the older portions, pale-isabelline on the thin, expanded, recent growth; margin acute, narrowly sterile, pallid, undulate, straight: context thin, 1–2 mm., pale-isabelline, punky-corky; tubes distinctly stratose, isabelline within, 2–3 mm. long each season, mouths regular, circular, 5 to a mm., white to isabelline, opaque, edges thick, firm, tough, obtuse, entire: spores globose, smooth, hyaline, 5 μ; hyphae hyaline, 4 μ; cystidia none.

Type collected on the Lamao River, Luzon, 500 m., on a decaying trunk, January, 1904, by R. S. Williams.

Fomes philippinensis Murrill, sp. nov.

Pileus dimidiate, sessile, bracket-shaped, applanate above, plane or convex below, 5–10 × 10–15 × 1–2.5 cm.; surface horny, thinly encrusted, radiate-rugose, glabrous, somewhat zonate, shallowly sulcate, becoming slightly rimose with age, pale-isabelline to dull-umbrinous; margin sterile, pallid, glabrous, zonate, rather thick, entire, at length somewhat truncate and furrowed: context punky, tough, isabelline, zonate, 5–10 mm. thick; tubes more or less distinctly stratified, 2–3 mm. long each season, isabelline within, mouths pallid, regular, circular, 5 to a mm., edges thick, obtuse, entire: spores ovoid, smooth, hyaline, 5 × 4 μ; hyphae hyaline, 3–4 μ; cystidia none.

Type collected on the Lamao River, Luzon, 700 m., on a dead trunk, March 23, 1904, by R. S. Williams.

FOMES SEMITOSTUS Berk. Jour. Bot. & Kew Misc. **6**: 143. 1854. (Type from the Khasia Mountains, India.)

Luzon: Lamao, 80 m., *Williams*; Mt. Mariveles, *Elmer 6050*. Leyte: Palo, *Elmer 7222*.

GANODERMA AMBOINENSE (Lam.) Pat. Bull. Soc. Myc. Fr. **5**: 70. 1889. *Agaricus amboinensis* Lam. Enc. **1**: 49. 1783. (Type from Amboina.)

Luzon: Lamaò, 80 m., *Williams*.

Ganoderma subtornatum Murrill, sp. nov.

Pileus sessile, short-stipitate, flabelliform, with a narrow base, applanate, slightly concave below, hard and rigid, 6–11 × 6–12 × 1 cm.; surface thinly encrusted, shining-black, except where covered with the brown conidia, glabrous, sulcate, radiate-rugose; margin truncate, slightly furrowed, sterile, entire: context 2–4 mm. thick, punky, white above, chestnut-colored below; tubes unstratified, slender, 5–8 mm. long, avellaneous-umbrinous within, mouths regular, circular, 5 to a mm., smoky-fuliginous, edges obtuse, entire: spores ovoid, pale-brown, finely asperulate, 9 × 6–7 μ; hyphae dark-brown, 5–6 μ; cystidia none: stipe lateral, compressed, 0–2 cm. long, 1.5–2 cm. thick, resembling the pileus in surface and substance.

Type collected on the Lamao River, Luzon, 100 m., on a decayed trunk, November, 1903, by R. S. Williams. Collected also on Mt. Mariveles, Luzon, November, 1904, by A. D. E. Elmer, *no. 6943*, and at Palo, Leyte, January, 1906, by Elmer, *no. 7213*.

Ganoderma Williamsianum Murrill, sp. nov.

Pileus sessile, dimidiate, compressed-ungulate or applanate, usually convex above, plane or concave below, subimbricate, rigid, 3–4 × 5–6 × 1–2 cm.; surface shallowly sulcate, slightly zonate, radiate-rugose, avellaneous, with narrow, dark zones when young, at length ochraceous-pulverulent from the secreted varnish, and finally glabrous, laccate, and bay or black; margin conchate at maturity, yellowish-brown, laccate, entire, sterile: context chestnut-colored, punky, soft, 3–6 mm. thick; tubes not stratified, slender, murinous-umbrinous within, hymenium white to ochraceous or melleous, mouths circular to slightly angular, regular, 5 to a mm., edges obtuse and entire when young, soon becoming thin: spores broadly ovoid, truncate, dark-brown, roughly echinulate, thick-walled, 8–9 × 12–14 μ; hyphae concolorous, 5–6 μ; cystidia none.

Type collected on the Lamao River, Luzon, 115 m., on a dead trunk, January, 1904, by R. S. Williams.

NIGROFOMES MELANOPORUS (Mont.) Murrill, Bull. Torrey Club **31**: 425. 1904. *Fomes melanoporoides* Ces. Myc. Borneo 6. 1879. (Type from Borneo.) *Fomes Cornu-bovis* Cooke, Grevillea **13**: 2. 1884. (Type from Malacca.) *? Polyporus cinereo-fuscus* Currey, Trans. Linn. Soc. II. **1**: 124. *pl. 19. f. 1.* 1876. (Type from India.)

Luzon: Lamao, *Williams;* Mt. Mariveles, *Elmer 6959.*

Pyropolyporus albomarginatus (Lév.) Murrill. *Polyporus albomarginatus* Lév. Ann. Sci. Nat. Bot. III. **2**: 191. 1844. (Type from Java.) *Polyporus Kermes* Berk. & Br. Jour. Linn. Soc. Bot. **14**: 49. 1875. (Type from Ceylon.) *Polyporus laeticolor* Berk. Jour. Linn. Soc. Bot. **16**: 46. 1878. (Type from the Philippines.) *Fomes pyrrhocreas* Cooke, Grevillea **14**: 11. 1885. (Type from New Guinea.)

Luzon: Lamao, 115 m., *Williams.*

Pyropolyporus caliginosus (Berk.) Murrill. *Polyporus caliginosus* Berk. Jour. Linn. Soc. Bot. **16**: 46. 1878. (Type from Philippines.) Not *Polyporus caliginosus* Ces. Myc. Borneo 5. 1879. (Type from Borneo.)

Leyte: Palo, *Elmer 7221.*

Pyropolyporus endotheius (Berk.) Murrill. *Polyporus endotheius* Berk. Jour. Linn. Soc. Bot. **16**: 47. 1878. (Type from the Philippines.)

Culion: *Merrill 3575.*

Pyropolyporus fastuosus (Lév.) Murrill. *Polyporus fastuosus* Lév. Ann. Sci. Nat. Bot. III. **2**: 190. 1844. (Type from Singapore.)

Luzon: Lamao, 80 m., *Williams.*

Pyropolyporus lamaensis Murrill, sp. nov.

Pileus dimidiate, sessile, thin, subimbricate, applanate, 2 × 4 × 0.3–0.7 cm.; surface finely tomentose, zonate, slightly sulcate, horny-encrusted, fulvous-chestnut; margin thick, obtuse, sterile, ferruginous, entire: context luteous to ferruginous, hard, woody, homogeneous, 3–5 mm. thick; tubes 2 mm. long, smoky-avellaneous within, mouths circular, regular, minute, 6 to a mm., opaque, dull smoke-colored, edges thin, entire: spores globose to ovoid, smooth, hyaline, 3.5–5 μ long; hyphae ferruginous, 4 μ; cystidia slender, pointed, 15–40 μ, dark-fulvous.

Type collected on the Lamao River, Luzon, on decayed wood, November, 1904, by R. S. Williams.

Pyropolyporus Merrillii Murrill, sp. nov.

Pileus sessile, ungulate, plane below, 4 × 6 × 3–5 cm.; surface finely tomentose, deeply sulcate, anoderm or slightly encrusted, hard, bay, becoming blackish and weathered in the older layers; margin fulvous, sterile, finely tomentose, obtuse, undulate: context dark-fulvous, hard, horny, 3–6 mm. thick; tubes indistinctly stratified, fulvous within, 2–4 mm. long each season, mouths fulvous, subcircular, regular, 4 to a mm., edges rather thick, entire: spores ferruginous-fulvous, copious, subglobose, smooth, 3–4 μ; hyphae concolorous, 4 μ; cystidia none.

Type collected in Culion, on decaying trees near the seashore, December 1902, by E. D. Merrill, *no. 3575.*

Pyropolyporus pectinatus (Kl.) Murrill. *Polyporus pectinatus* Kl. Linnaea **8**: 485. 1833. (Type from the East Indies.) *Fomes pullus* (Berk. & Mont.) Cooke, Grevillea **14**: 19. 1885. (Type from Java.)

Luzon: Lamao, 80 m., *Williams*; Mt. Mariveles, *Elmer 6933.* Palawan: Ewiig River, *Merrill 3586.*

Pyropolyporus Williamsii Murrill, sp. nov.

Pileus bracket-shaped, sessile, dimidiate, plane above, convex below, very hard, horny and brittle, 5–8 × 8–15 × 1–2 cm., surface finely tomentose to glabrous, dark-bay to black, horny-encrusted, deeply and roughly sulcate, somewhat tuberculose, slightly cracking with age; margin isabelline, sterile, rounded, entire or undulate: context 8–10 mm. thick, ferruginous, hard, radiate-striate, with white dendroid markings; tubes distinctly stratified, 2–3 mm. long each season, umbrinous to avellaneous within, mouths circular, avellaneous, opaque, regular, 5 to a mm., edges thick, obtuse, entire: spores subglobose, smooth, hyaline, 3–5 μ; cystidia dark-fulvous, ventricose, pointed, 15–30 μ long.

Type collected on the Lamao River, Luzon, 80 m., on a dead trunk, December, 1903, by R. S. Williams. What appears to be a young, deformed specimen of this species was collected on Mt. Banahao, Luzon, 500 m., on dead timber, May, 1906, by A. D. E. Elmer, *no. 7556*.

Subfamily DAEDALEAE

DAEDALEA AMANITOIDES Beauv. Fl. Owar. **1**: 44. *pl. 25.* 1804. (Type from Wari.) *Daedalea Palisoti* Fr. Syst. **2**: 335. 1821. *Lenzites Palisoti* Fr. Epicr. 404. 1838. Afzel. Fung. Guin. **1**: *pl. 11. f. 23. a. b.* *Daedalea repanda* Pers.; Gaud. Voy. Freyc. Bot. 168. 1826. (Type from the island of Rawak.) Mont. Cuba 382. *pl. 14. f. 4.* 1842. *Lenzites repanda* Fr. Epicr. 404. 1338. *Daedalea applanata* Kl. Linnaea **8**: 481. 1833. (Type from Mauritius.) *Lenzites applanata* Fr. Epicr. 404. 1838. *Lenzites pallida* Berk. Lond. Jour. Bot. **1**: 146. 1842. (Type from Manila.) *Lenzites platypoda* Lév. Bonite Crypt. **1**: 184. 1844–1846. Ann. Sci. Nat. Bot. III. **2**: 180. 1844. (Type from Manila.)

Luzon: Lamao, 70 m., *Williams*; Mt. Mariveles, *Elmer 6942*. Leyte: Palo, *Elmer 7218*. Culion: *Merrill 3574*.

DAEDALEA HOBSONI Berk. Jour. Linn. Soc. Bot. **13**: 165. 1873. (Type from Australia.) ? *Trametes colliculosa* Berk. Lond. Jour. Bot. **6**: 506. 1847. (Type from Ceylon.)

Luzon: Lamao, 115 m., *Williams*; Mt. Mariveles, *Elmer 6914, 6928, 6948*; *Merrill 3507*. Culion: *Merrill 3608*.

Gloeophyllum edule Murrill, sp. nov.

Pileus imbricate, sessile, dimidiate, conchate or applanate, slightly decurrent at times, 4–7 × 6–10 × 0.3–0.6 cm.; surface short-tomentose to almost glabrous behind, subzonate, ochraceous-isabelline to pale-fulvous, becoming bleached with age, with a few, shallow, concentric furrows; margin acute, entire or undulate, ochraceous, tomentose, brownish when bruised: context ferruginous, punky, 2–4 mm. thick, soft enough when young to be eaten by the native Igorrotes; hymenium lenzitoid, furrows several times forked, 2–4 mm. deep, about 1 mm. broad, edges pallid to avellaneous-fulvous, entire and rather thick when young, becoming thin and somewhat lacerate-dentate with age: spores elongate-ellipsoid, smooth, hyaline, 7 × 3 μ; hyphae pale-ferruginous, 3–4 μ; cystidia none.

Type collected at Baguio, Luzon, 1750 m., on fallen dead logs of *Pinus insularis*, September, 1904, by R. S. Williams.

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SCANDINAVIANS

Who Have Contributed to the Knowledge of the Flora of North America.

By PER AXEL RYDBERG

NEW YORK
1907.

From the Augustana Library Publications. 1907.

SCANDINAVIANS

Who Have Contributed to the Knowledge of the Flora of North America. *

When we this year celebrate the two hundredth anniversary of the birth of Linnæus, the first questions that suggest themselves to us are: "What did the immortal Swede achieve for botany and zoology, the two sciences he loved so well?", and "Has the work of Linnæus any direct bearing upon the botany and zoology of America?"

The first of these questions has been answered so many times; and will be answered over and over again this spring at hundreds of places where the anniversary will be celebrated. I say hundreds, for there will scarcely be any college or university of any repute, where natural history is taught, throughout the whole world, which will not have a commemorative celebration of some kind; and what would be more natural for a speaker of the day or an *in memoriam* writer to dwell upon than the life work of the man in whose memory the celebration is held. To exploit the achievements of Linnæus will therefore be left in the hands of many abler men than the present writer is.

The second question the writer has been asked to answer in a short address at the celebration to be held here in New York on the 23rd of May. Undoubtedly, it will be answered at more than one place in this country this spring.

When the writer some time ago was asked by Professor J. A. Udden to prepare a "fest-skrift" for the Linné anniversary at Augustana College, Rock Island, Illinois, he hesitated very much whether to accept this honoring invitation or not. He did not know if it would be possible for him in the short time, and with all the busy hours of a curator at an institution such as the New York Botanical Garden, to prepare a memoir creditable to such an occasion. At last he dared to undertake the work, and hopes that the institution for which it has been prepared and the anthor's contemporaries in general will receive it as it is, and have forbearance with its shortcomings.

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After accepting the invitation, the writer had to choose a subject. As he did not dare to undertake the answering of the first question of the day, because it would have been too hard a task and he would have had too many competitors, and as it was only reluctantly he had agreed to make a short address, in which he would try to answer the second, he hardly knew what to write about. His national pride helped him in choosing the subject and he will try to answer the question: "Have the Scandinavians contributed anything to the knowledge of the flora of North America?"

Swedes, Norwegians, Danes, Icelanders, and the descendants of Swedes who settled in Finland a few hnndred years ago, are in reality but one nation, although ruled by four different crowned heads. Many of these Scandinavians have chosen, like the present writer, to settle on this side of the Atlantic and to swear allegiance to the stars and stripes. They have not thereby lost their nationality, nor its virtues. As Scandinavians have also been counted a few men of Scandinavian parentage (of the first generation), if this was known to the writer.

With North America the writer understands not only the United States and Canada, but the whole continent north of the Isthmus of Panama and adjacent islands, hence comprising also Mexico, Central America, and the West Indies. This view is the one generally adopted by American botanists, since the acqusition of Porto Rico and the overtaking of the Panama Canal work by the United States. From that time the heaviest work on the flora of these countries has shifted from Europe to America.

When trying to write a sketch of the Scandinavians more or less connected with the history of botany of North America, the writer naturally has to deal with this history and with the history of botany in general. It may not be amiss to state that the history of botany is here taken in a rather narrow sense, including only that of systematic botany, plant geography and related branches, not of plant physiology, nor general morphology, etc.

The best history of botany (or we may say, of botanists) in the library of the New York Botanical Garden is Emil Winckler's

Geschichte der Botanik. Unfortunately, this history brings us only up to 1850. Winckler divides the history into the following periods:

The ancient writers.
Medicus—Bauhin, 1478—1601.
Bauhin—Tournefort, 1601—1694.
Tournefort—Linnæus, 1694—1735.
Linnæus—Jussieu, 1735—1789.
Jussieu—R. Brown, 1789—1817.
R. Brown—............, 1817—1850.

Pritzel divides it into the following periods:

Ancient writers.
Tournefort—Linnæus, 1694—1736.
Linnæus—R. Brown, 1736—1810.
R. Brown—DeCandolle, 1810—1824.
De Candolle—............, 1824—......

These two writers agree in regarding Tournefort, Linnæus, and Robert Brown epoch-making botanists. There is no question that the two first were. As to Robert Brown, there is no doubt that he was one of the greatest systematic botanists the world has produced, and scarcely anyone has known as many plants as he; but as far as the botany of North America is concerned, the writer cannot see that a new epoch began either 1810 or 1817. There are many more reasons for assigning the beginning of new epochs with Jussieu and De Candolle, or rather with the appearance of the works in which they proposed their new systems of classification.

As far as the North American botany is concerned, new epochs apparently began about 1840 and 1890. The beginning of the first of these was too near the time when Winckler and Pritzel wrote, and was naturally overlooked by them.

The writer has adopted in general the periods by Winckler, but with some modification in the later ones.

1. MEDICAN PERIOD, 1478—1601.

This period extends from the time of Medicus to the appearance of Kaspar Bauhin's Pinax. During this time nothing of any value was written on American botany except the work of Hernandez, who traveled in Mexico in 1570—6. Only a portion thereof was published 1615, 1648, 1651, and 1791. So even the publicationof Hernandez's work does not belong to this period.

Nothing was contributed to the knowledge of the American flora by Scandinavians.

2. BAUHINIAN PERIOD, 1601—1694.

This period extends from Bauhin's Pinax to Tournefort's Institutiones. The former of these was a remarkable book for its time. It aimed to catalogue and describe all known plants. The names of the plants and the descriptions were of the usual form of the the time. Of course, the work is written in Latin. The names consist of a noun together with a descriptive phrase of one or more adjectives or adjective modifiers. The descriptions are crude, but often as good as were used by the immortal Linnæus himself, 150 years later.

During this period the flora of the West Indies and Mexico was explored and described by Sloane, a noted Irish physician and naturalist, and the Jesuit Barnabas Coba; but nothing was done by Scandinavians.

3. TOURNEFORTIAN PERIOD, 1694—1735.

Tournefort's Institutiones was the epoch-making book. In this appear for the first time botanical genera in their modern sense. Tournefort had in many cases even a clearer idea of generic limitations than Linnæus himself. The majority of the genera in the Genera Plantarum of the latter were adopted from this work of Tournefort. Tournefort's descriptions are about as good as those of Linnæus, and have the advantage of being accompanied by illustrations. What Tournefort's Instiutiones lacked was the systematic arrangement.

During this period the flora of North America was investigated by Plumier, who made four journeys to this continent, W. Houstoun, who collected in the West Indies and Mexico, John Lawson, in Carolina, and M. Catesby, in Virginia, Florida, and the Bahamas.

The first Scandinavian who, as far as the writer knows, contributed to the knowledge of the flora of North America, was Hans Egede, who spent fifteen years as missionary in Greenland. Greenland is not always counted to America, but there is no reason why it should not be. It is much nearer America than Europe. Even botanically it belongs to the former. It is true that it contains many plants common to northern Europe but not found elsewhere in North America, but still it is more American than European. The larger number of plants growing in Greenland are circumpolar ones, i. e. found in America as well as in Europe and Asia. If these are excepted, the flora is decidedly more American than European, especially in the northern part. This is not the case at all with the neighboring Iceland. The latter could be counted geographically to America, but not so botanically. Its flora consists almost exclusively of plants common to it, northern Scotland, northern Scandinavia, Spitzbergen, etc., with a few common to it and Greenland but with no American plants, if the circumpolar ones are excepted.

Hans Egede was born at Trondenæs, Norway, the 31st of January, 1686. He served some years as a minister in his native land. He went to Greenland as a missionary in 1721, and stayed there till 1836. He died at Stubbekjöbing on the Island of Falster, Denmark, the 5th of November, 1758. He made a collection of plants, which are still preserved at Copenhagen. After his return from Greenland, he published a very interesting account of the country, its people, fauna and flora, under the title:

Det Gamla Grönlands Nye Perlustration eller Natural-Historia, 1741. (Translated also into French.)

It is claimed that what most tempted Egede to go to Greenland was the idea that he might find there some descendants of the old Norwegian and Icelandic settlers from the time of Leif Ericson. He did not find any Norsemen, although he visited all the places where the old colonies were supposed to have been. The temporal as well as the spiritual welfare of the heathen Greenlander weighed heavily upon his heart. In order to alleviate their wretched condition, he induced a Norwegian company to establish trading posts at several places. After the company had lost one of its best vessels, and as the trading never had been a very paying business, the company decided to withdraw its men and discontinue the trade. This happened in 1726. Egede and his family and a few volunteers remained. Egede sent such a strong plea to the king of Denmark, that in the second year a vessel was sent to Greenland, the Danish government reopened some of the posts, and has carried on from that date a regular communication and continuous commerce with the island.

Paul Egede, son of Hans Egede, was born in 1708, became a missionary to Greenland in 1734, received the title of theological professor in 1761, and that of bishop in 1779. He died in 1789. He has left the following publications:

Herbarium vivum samlet i Grönland ved Colonierne Christianshaab og Godthaab, 1789.

Efterretninger om Grönland, uddragne af en Journal holden fra 1721 til 1788.

4. LINNEAN PERIOD. 1735—1789.

A new epoch began with the appearance of Linnæus's Genera Plantarum. In this Linnæus's new system of classification was used. Before this time there had been no definite system, or there had been used only such crude systems as we sometimes find to-day in some popular books, where, for instance, the plants are classified according to the color of the flowers. Linnæus based his system on the number and different arrangenmet of the stamens and pistils. This was an artificial system, and Linnæus knew it to be so. He once expressly stated that he expected it to be superseded by a more natural one, where the relationship of the plants would be better shown. The Linnean sexual system was and is a very convenient one, and has been used more or less up to our times, where the aim has been to give a key, by the means of which one could quickly determine the names of the plants. That Linnæus saw the natural relationship of plants is shown by the fact that he later gave names to several of our modern families of plants, and that he arranged his artificial system so that several of his classes or orders are practically equivalent to modern families, as for instance the 14th, 19th and 20th classes, and his orders of the 15th and 17th classes.

Another invention of his was the uniform binomial names of the species. This was introduced in his "Species Plantarum" of 1753. Before Linnæus, the botanists, especially since the time of Tournefort, recognized genera in the same sense as we now do, and designated them by Latin nouns In order to designate the species, they added to these nouns descriptive phrases consisting of one or usually several adjectives*, or their equivalents. Linnæus reduced the specific name to one adjective. We find occasionally binomial names in works before Linnæus, but he was the first to use consistently only such names.

By these two systems it was from this time easy to tabulate and arrange the known facts about plants, and it was comparatively easy to find the description of a certain plant; for each genus had a certain place in the system and had only one name, and the species had only one additional name to distinguish it from other species of the same genus, in a similar way as John Smith and Andrew Smith of the same family have different personal names.

During this period many native American botanists explored the country, as John Clayton, John Mitchel, and Thomas Walter the southern states, C. Colden, Jane Colden, William and John Bartram the northern. Many Europeans made extensive travels in this continent, as Patrick Browne, N. J. von Jacquin and Swartz in the West Indics, and Miguel Venegas and A. Mensies on the Pacific coast.

The following Scandinavians made contributions to the knowledge of the North American flora during this period:

A. United States and Canada.

Pehr Kalm was born at Nerpis, Finland, in 1715, and died as professor at the University of Åbo, the 16th of November, 1779.

In the seventeen hundred and nineties, Baron Sten Carl Bjelke, then the vice president of the court of appeals (hofrätten) of Finland, proposed to the Royal Swedish Academy of Sciences at

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* An illustration of the difference in the nomenclature of Linnæus and that of his predecessors is found below on page 12 in the citation from Kalm, in which the latter first gives the old way of naming the plant, named after him, and the Linnean way, viz., *Kalmia latifolia*.

Stockholm to send a botanist to Siberia and Iceland, which are on the same latitude as a part of Sweden, to collect seeds of plants as would "improve the Swedish husbandry, gardening, manufactures, arts, and sciences." Dr. Linnæus suggested that North America would be a better country than either. About the same time a Captain Triewald gave in Stockholm an exhibition and lecture on his observations on silk-culture. As Linnæus had described a species of mulberry[*] from North America and native of a climate similar to that of Sweden, this gave additional strength to the choice of North America. When Count Tessin, who could nearly always have his own way, and who was in favor of the project, became president of the Royal Academy, it was decided to send Professor Kalm. An appeal was sent to the three universities of Sweden, at Upsala, Lund, and Åbo, to contribute what they could for the advancement of science. Åbo was the first one to answer, and sent a small sum, Lund had nothing to spare, but Upsala contributed liberally, considering the times and the country. Now-a-days, $450 seem to us rather a small sum. With the countributions from other sources, the fund amounted to about twice that sum. Professor Kalm, however, spent not only this and his own salary, but about $650 of his own money, and the journey left him with very limited means for the rest of his life.

After passports had been secured from the courts of London, Paris, Madrid, and the Hague, Kalm sailed from Gothenburg the 11th of December, 1747, accompanied by Lars Jungström, a gardener by profession. Overtaken by a severe storm, the vessel had to put in at Grimstad, Norway, where the travelers had to stay till the 8th of February, 1748. They arrived at London the 17th of the same month, stayed in England till August 15, and arrived at Philadelphia the 26th of September.

In Philadelphia Kalm stayed about a month, and made there the acquaintance of John Bartram, the most prominent American naturalist at that time. Then he set out on a journey to New York, passing through New Frankfort, New Bristol, Pa., Burlington, N. J., then the residence of the governor, Trenton, "Prince-town", New Brunswick, and Elizabeth, returning to Philadelphia Nov. 5.

In November he visited Racoon, N. J., where a number of

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[*] This was *Morus rubra* L., which can be grown in southern Sweden, but, unfortunately, thi species is not well adapted to silk-culture.

Swedes lived. Kalm afterward published three volumes on his travels. In these he describes very minutely everything he saw, the people, their industries and customs, the conditions and nature of the country through which he traveled. Of the animals and plants he met with, he gave only short descriptions, as he intended to publish these more extensively in a scientific work in Latin. In the diary of his stay in Racoon, he describes what the Swedes called the spoon-tree, because the Indians were said to make spoons from its wood. Kalm adds: "The English call this tree Laurel, because its leaves resemble those of the *Laurocerasus.* Dr. Linnæus, conformable to the peculiar friendship and goodness with which he has always honored me, has been pleased to call this tree, *Kalmia foliis ovatis, corymbis terminalibus* or *Kalmia latifolia.*"

With the exception of a few days spent on a revisit to Philadelphia and a short visit to Penn's Neck, Kalm staid at Racoon the whole time till May 21, 1749. From June 3 to June 10 he was in New York. From there he sailed in a yacht to Albany. From there he traveled through Saratoga, Fort Nicholson, Fort Anne, Fort St. Frederic, Fort St. John, and Prairie de la Magdelene to Montreal, at which place he arrived on the 24th of July. He arrived at Quebec the 5th of August, visited several neighboring places, and returned to Montreal the 15th of September.

The three volumes of his "En resa till Norra Amerika" describes his travels up to this period. Evidently he intended to publish the account of the remainder of his stay in North America, but it was never done, probably on account of lack of funds. In the preface is given a synopsis of his travels. From this we find that he returned to Philadelphia the same fall. In 1750 he visited western Pennsylvania and the shores of New Jersey. After this he undertook his second long journey, through New York, the Blue Mountains, to Albany, then along the Mohawk River, visited the Iroquois Indian nations, the Mohawks, Oneidas, Tuskaroras, Onandagas, and Kayugas, saw the shores of Lake Ontario and Niagara Falls, and returned to Philadelphia in October. In a letter to Bartram he has given a vivid and most interesting description of his impressions at Niagara.

In 1751 he returned home by the way of England, and arrived at Gothenburg on the 16th of May. He resumed his duties as professor at the University of Åbo. In his private little garden he raised many of the seeds he had gathered, and many more were cultivated in the Botanical Garden at Upsala. As stated before, he published:

En resa till Norra Amerika (A Journey to North America), in 3 volumes, 1853—'61. [This has been translated into German and English, and is one of the best accounts of this country at that period.]

Norra Amerikanska färge-örter, published in 1763.

He intended to publish a larger descriptive work on the plants and animals he met with on his journey, but this was never done, very likely because he had spent all his funds. All, or at least most of his plants were published by Linnæus in his "Species Plantarum."

Carolus Linnaeus or CARL VON LINNÈ was born at Råshult, Småland, Sweden, the 13th of May (old style), 1707, and died at Upsala the 10th of January, 1778. There is no need of going into details of his life-history, for it will be given extensively over and over again this year. Only a few words may be given to show his work on American botany. I shall give it more extensively elsewhere.

He became acquainted with the North American plants from the finely illustrated works of Plumier, Plukenet, Catesby, Sloane, and Gronovius; also those of Petiver, Morrison, and Cornuti. Through Gronovius he had a chance to see Clayton's collection. Sloane's and Catesby's plants he saw on his visit to England. He described himself the plants collected by Kalm. A few American plants were already under cultivation. These were all incorporated in the first edition of "Species Plantarum." He afterwards received plants from Barthram and from Colden and his daughter Jane. He corresponded with John Ellis, a resident in the West Indies, and Dr. Gardner, who botanized in Carolina and Florida. Later he purchased a set of West Indian plants collected by Patrick Browne, and received a part of Jacquin's collections through exchange. These were described in the 10th edition of his "Systema Naturæ" and in the 2nd edition of "Species Plantarum." In all, he described about 2,000 North American plants.

The works which in part bear on North American botany are:

Species Plantarum, 1753; Edition 2, 1762—'63.

Systema Naturæ, Ed. 10, 1758—'59.

Daniel Carl Solander was born the 12th of February, 1733, at Piteå, Sweden. In 1759 he moved to England, and became librarian of the British Museum in 1765. Solander died in London the 13th of May, 1782. Together with Banks, he was a botanist on Captain F. Cook's first voyage around the world in 1768—'71. As a result of this journey the following scientific work was published by the trustees of the British Museum in 1900—'05: Illustrations of the Botany of Captain Cook's first voyage around the world. Solander also helped Aiton in publishing:

Hortus Kewensis, 1789.

In this Solander has contributed the descriptions of many new plants from America as well as elsewhere. Six of the new genera published in Swartz's West Indian flora are really from Solander's hand, as Swartz found the descriptions as well as the names in Solander's manuscript in the Banksian herbarium.

B. Greenland and Arctic America.

Many of the men in charge of the Danish trading posts in Greenland, established at the instigation of Hans Egede, and many of the sea captains engaged in the trade on Greenland or whaling near its coasts, brought home botanical specimens. One of the earlier and the most important of these was,

Carl Peter Holböll, who was born at Copenhagen the 31st of December, 1795. In 1821 he was appointed lieutenant in the marine, and some years later captain and governor of one of the colonies in Greenland. After his return to Denmark, he sailed in 1856 to revisit Greenland, and neither he nor his vessel was ever heard from. He was interested in both zoology and botany, and published an article on the birds of Greenland. His collection of plants is at the botanical museum at Copenhagen. At least one plant, *Arabis Holboellii* of the mustard family, is named after him.

The plants from the older of these collections, as well as those made by Egede and his son, were mostly described in the splendid work that bears the name *Flora Danica.* It is a large folio in sixteen volumes, and was intended to figure every plant growing in the kingdom of Denmark and its possessions. It includes, therefore, Norway, Faroe Islands, Iceland, Greenland, Schleswig-Holstein, and Oldenburg, which all at some time have belonged to Denmark. It was begun in 1764 by Öder, and was concluded in 1871.

Georg Christian Öder was born at Anspach, Germany, the 3rd of February, 1728. He took the degree of doctor of medicine in 1749, later moved to Denmark, where he was appointed professor at the University of Copenhagen in 1754, became "Stiftsamtman" at Drontheim, Norway, in 1773, moved to Oldenburg in 1773, where died the 28th of January, 1791.

His most prominent botanical work was the above mentioned *Flora Danica*, of which he published the first three volumes. These contain a large number of Greenland plants.

Christen Friis Rottböll was born at Hörby, Zealand, Denmark, the 3rd of April 1727, became doctor of medicine in 1755, professor in 1756, and director of the botanical garden in Copenhagen in 1776. He died in Copenhagen the 15th of June, 1797.

The only article from his hand that bears directly on American botany is,

Afhandling om en Deel rare Planter, som i Island og Grönland ere fundne, etc. 1770.

Anders Johan Retzius was born at Christianstad, Sweden, the 3rd of October, 1742, became doctor of philosophy in 1766, and was professor at the University of Lund 1777—1812. He died at Stockholm the 6th of October, 1821. Linnæus, Læstadius, Wahlenberg, and Retzius are those of the older botanists who did the most to make the flora of Lapland known. They therefore laid the foundation to the knowledge of the Arctic vegetation in general. Among other botanical works he published the following, which also included Greenland:

Flora Scandinaviæ Prodromus, 1779 [together with two supplements].

C. West Indies and Central America.

Carolus Linnaeus (See above).

Carl Gustaf Sandmark, a pupil of Linnæus, wrote a dissertation which was based on a collection secured by Linnæus from P. Browne. In reality this did not contain anything new, as the species had already been described in "Systema Naturæ" by Linnæus. The only value Sandmark's dissertation has is that it gives more extensive descriptions.

Flora Jamaicensis, 1759.

Gabriel Elmgren, also a disciple of Linnæus, wrote a dissertation based on the same collection of P. Browne. What is said of Sandmark's dissertation, applies also to this. Elmgren's work, however, contains many species not found in Linnæus' "Systema." Three of these are accompanied by descriptions and belong by right to Elmgren, although they as a rule have been credited to Linnæus.

Plantarum Jamaicensium pugillus, 1759.

Daniel Carl Solander (See above).

Carl von Linné, f., the son of the immortal Linnæus, was born at Falun, Sweden, the 20th of January, 1741, became professor of medicine in 1763, and died at Upsala the 1st of November, 1783.

As far as the writer knows, he published only a few Central American plants collected by Mutis.

Supplementum Plantarum Systematis vegetabilium, 1781.

Olof Swartz was born at Norrköping, Sweden, the 21st of September, 1760. His father, whose name was also Olof Swartz, was a factory owner and a man of some means. This fact made the son independent and able to spend money both in travels and in publishing his works. Olof Swartz was a pupil of Carl von Linné, the younger. As a student he showed such ability that his teacher said of him: "*Botanices studiosus optimæ spei.*" In 1780 and 1783 he took the two preliminary examinations then required for the degree of doctor of medicine. During the summers of this period he undertook several botanical expeditions to different provinces of Sweden and made several new discoveries.

Swartz had for some time contemplated making a journey into the tropics, and in 1783 he was ready to go. He went on board the 5th of August, and sailed in a merchant vessel to Boston, where he landed the 3rd of October. He did not intend to stay there, but took the first opportunity offered him to go to Jamaica. He left Boston on the 26th of November and landed in Montego Bay on the 5th of January, 1784. He set to work with an untiring zeal to make as thorough a survey of the natural history of the island as possible. Not long after his arrival he was invited to remain as government botanist, but he declined. In 1785 he spent a few months in Cuba and San Domingo, and returned to Jamaica. According to Wikström, he also visited Porto Rico, but this is denied by Urban.

In 1786 Swartz went to England to compare his collections with the Linnæan and Banksian herbaria there. During his stay he was offered another position, viz., to go to India as physician of the East India Company; but he declined, having decided to serve his own native country. His collections were very rich, and his *Flora Indiæ Occidentalis*, the ultimate result of his travels and labor, is the foundation of our knowledge of the flora of the West Indies. It contains the descriptions of 892 species of plants. Of these 723 were new to science.

After his return to Sweden, Swartz continued his botanical explorations in different parts of Sweden. In 1802 he was called to become the successor of Prof. Lepechin as director of the Royal Academy of Sciences at St. Petersburg, but again he declined. He was appointed director of the Royal Academy at Stockholm in 1807, made a knight of the Order of Vasa in 1908, and professor of the Royal Carolinian Medico-Chirurgic Institute at Stockholm in 1814. He died the 19th of September, 1818.

Swartz's knowledge of American plants, however, was not limited to his own collections. While in England, he studied the collections found in the herbaria of Sloane, Plukenet, Petiver, and Banks. He corresponded freely with such men as Schreber, Willdenow, Schræder, Persoon, Mohr, Hooker, and Fischer, the prominent botanists of his time. He received from Rev. Muhlenberg in Pennsylvania a fine collection of American plants collected in 1710 and 1711. From these he described six new species of mosses.

In 1817 Rev. Forström, then residing on the island St. Bartholomew, sent him a large collection of Antillian plants. These furnished the material for his "Flora Bartholomensis et Guadaloupensis", containing 34 new species.

He was an acknowledged authority on ferns, mosses, and lichens. He was the father of fern-knowledge; his *Synopsis Filicum* made a revolution in that science. He was one of the first to adopt and apply the system of genera and species of mosses by Hedwig, the father of bryology, and he knew almost as much about lichens as his friend Acharius. In his books on these three classes of plants are found numerous descriptions of North American plants.

The following publications from Schwartz's pen refer wholly or partly to North American plants:

Tolf nya slag af Urticæ-släktet från Vestindien, 1787.

Beskrifning på nio nässlor (*Urtica*), hvilka nyligen på Jamaica blifvit upptäckta och beskrifna af O. Swartz, 1787.

Nova Genera et Species Plantarum, etc., 1788.

Cinchona augustifolia, en okänd växt från Västindien, 1788.

Solandra, ett nytt släkte från Västindien, 1788.

Quassia excelsa, en ny växt från Västindien, 1788.

Stylanthus, ett nytt örtsläkte, 1788.

Observationes botanicæ quibus plantæ Indiæ occidentalis, 1791.

Icones plantarum incognitarum quas in India occidentale delexit atque delineavit, 1794.

Flora Indiæ occidentalis aucta atque illustrata, etc., 1797—1806.

Synopsis Filicum, 1806.

Lichenes Americani, 1811.

Flora Bartholomensis et Guadaloupensis. 1825 & 1827.

5. JUSSIEUAN PERIOD, 1789—1819.

This period begins with the publication of the *Genera Plantarum secundum ordines naturales disposita* by Antoine L. de Jussieu. In this appears for the first time a system of classification based on the natural relationship of the plants. This system was in reality founded by his uncle, Bernard de Jussieu, but never published. The system was much more natural than the sexual system of Linnæus, but was also much more complicated. As it had many inconsistencies, and as there was no uniformity in the names of the families, it did not receive the adherents that it deserved, and there are few books in which we find it used during this period. Even if the Jussieuan system of classification did not leave deeper marks on the period which bears its name, it is evident that a new era began at this time, a very active one, especially in systematic botany, with such systematists as Willdenow, Aiton, Salisbury, Persoon, Sprengel, and Robert Brown, the latter, however, belonging just as much to the next period.

Before this time nothing had been published that exclusively treated on North America except Walter's "Flora Caroliniana", which appeared the year before Jussieu's "Genera"- During this period were published all the older floras of this country, viz., those of Michaux, Pursh, Barton, and Bigelow, and Nuttall's "Genera". Elliott's work was published a few years after the beginning of the next. H. Muhlenberg and C. C. Robin belonged to this time. Lewis and Clark made their famous expedition across the continent, A. Poiteau, John Lunan, and G. Richard de Tussac explored the West Indies, David Cranz, a Moravian missionary, collected in Greenland, and another one of the same creed, Kolmeister, in Labrador.

The following Scandinavians partook in the work; none of them, however, contributed anything important to the knowledge of the flora of the continent. Their work was mostly limited to the West Indies.

A. West Indies.

John Ryan was a planter on St. Croix. When and where he was born and when he died, I have not been able to ascertain, but he was a contemporary of Vahl's. He made several journeys to different parts of the West Indian islands and to Surinam and Brazil. He corresponded with and sent numerous specimens to Vahl.

Julius Philip Benjamin von Rohr, an officer of the garrison of the Danish West Indies, served from 1757 as civil engineer, and from 1765 as superintendent of constructions at the government buildings and forts. In 1787—'91 he made a series of journeys in the interests of cotton culture, and died as lieutenant colonel in 1793, on a journey from North America to Guinea. He was an ardent collector, and described 8 new genera of plants from St. Croix, Montserrat, Guadeloupe, and Martinique. His collections were afterwards elaborated by Vahl. At least one publication is from his hand:

Plante-Slægter med tilföiede Anmærkninger af Hr Professor Vahl, 1792.

Hans West was born in 1758 at Mesinge, on Hindsholm, Fyen, Denmark. In 1788—1800 he was the president of the school at Christianssted on St. Croix. In 1802 he was appointed minister to Holland, and died at Cassel, returning from a journey to France 1811. He made in the Danish West Indies and Porto Rico extensive collections, which were sent to Vahl. He published the following, a work of 363 pages:

Bidrag til Beskrivelse over Ste. Croix, med en kort Udsigt over St. Thomas, St. Jean, Tortola, Spanishtown og Crabeneiland, 1793. [Several new species are there published].

Martin Vahl was born at Bergen, Norway, the 10th of October, 1749. He became lector at the Botanical Garden at Copenhagen in 1779; director of the Botanical Garden in 1800; profes- at the university in 1801, and died the 24th of December, 1804. He studied under Linnæus in 1769—'75, and edited *Flora Danica,* Vols. 6 and 7, in 1787—1803. He was specially interested in the flora of the West Indies. The plants he described were collected by von Rohr at St. Croix, Monserrat, Guadeloupe, and Martinique; by Dr. Ryan at Monserrat, St. Croix, and St. John; by Hans West on the Danish West Indies; by Mertfelt on Guadeloupe, and Dr. Pflug on St. Croix.

The following, referring to American plants, are from him:

Flora Danica, Vols. 6 and 7, 1787—1803.
Eclogæ Americanæ, 1796—1807.
En deel Kryptogamiske Planter fra St. Croix, 1802.

Om Slægtet *Cinchona* og dens Arter, 1797.

Icones illustration, plantarum Americanarum in Eclogis descriptarum inservientes, 1798—'99.

Anmærkninger til Oberst-lieutenant von Rohrs Beskrivelse over nogle Planter, 1793.

Beskrivning over *Stellaria Grænlandica* og *Dryas integrifolia*, 1797.

Samuel Jahlberg, a Swedish physician, came to St. Bartholomew in 1785, soon after that island had become a Swedish possession. He published:

Utdrag af samlingar till naturalhistorien öfver ön St. Barthelemi i Västindien, 1786.

Bengt Anders Euphrasen, a botanical student, undertook in 1788 a journey to the West Indies under the auspices of the Royal Swedish Academy of Sciences, and visited St. Bartholomew, St. Eustatius, and St. Kitts. After his return he published:

Beskrifning öfver svenska västindiska ön St. Barthelemi samt öarne St. Eustache och St. Christopher, 1795.

Paul Erdman Isert was born in 1757, and in 1783 went out as head physician of the Danish Colonies in Guinea, which he left in 1787 and sailed in a slave-ship to the West Indies. He visited St. Croix, St. Thomas, St. John, St. Eustatius, Guadeloupe, and Martinique. He returned to Copenhagen, where he died in 1789. He published:

Reise nach Guinea und den Caraibischen Inseln im Columbien, 1788,

Rev. Forström. Nothing more is known to the writer than that he was a Swedish clergyman residing on the island of St. Bartholomew, and sent a large collection to Swartz in 1817.

Olof Swartz (See preceding period.)

6. CANDOLLEAN PERIOD, 1819—1840.

This period began, in the writer's opinion, rather with the appearance of the second edition of Augustine Pyramus de Candolle's *Theorie elementaire de la Botanique* in 1819, than with that of the first volume of his "Prodromus", in 1824: for the epoch-making publication was the publication of his system of classification. It is true that his system had already been published in 1813 in the first edition of the "Theorie;" but it received considerable modifications in the second edition, where it is practically as we know it to-day.

De Candolle's system was based to a great extent on that of Jussieu; but not only had the related genera been brought together into families, but the related families into orders, and arranged in a series. Except in a few cases, he had formed the name of each family from the name of a representative genus belonging to it by suffixing the ending *-aceæ*, as, for instance, *Rosaceæ* from *Rosa*. His system was adopted almost immediately by the leading botanists of the world, and the Natural System has from that time prevailed over the artificial Sexual System of Linnæus.

Before this time nearly all botanical publications relative to the flora of North America had been made by foreigners. From this time on, at least as far as the United States and Canada are concerned, the bulk of the published works is from the hands of native Americans. During this period lived here the following botanists: Nuttall, A. Eaton, Schweinitz, Barton, Rafinesque-Schmaltz, Torrey, Beck, Riddell, Engelmann, Darlington, Elliott, and Gray. Douglas and Drummond made their trips across the continent. E. Meyer explored Labrador; de la Pylaie Canada; Scoresby, Ross, Parry, and Richardson the Arctic regions; Maycock, Ehrenberg, and Macfadyen the West Indies; Llave, Lexarza, Schlede, Deppe, Moricand, Hartweg, and Ehrenberg Mexico.

None of the Scandinavian botanists visited the northern part of the continent proper, and none wrote specially on the flora of the United States or Canada; but two of the most prominent Swedish botanists published works in which numerous North American plants are described. These were:

Carl Adolf Agardh was born at Båstad, Sweden, the 23rd of January, 1785, received his Ph. D. in 1805, became docent at Lund in 1807 and professor in 1812, was appointed bishop of Karlstad, where he died the 28th of January, 1859. He was an ardent student of sea-weeds, and can be called the father of algology. His work was continued by his son, Jacob Georg. The elder Agardh has, as far as the writer knows, published nothing that bears exclusively on American botany; but in his principal works he describes many American plants. These works are:

Species algorum, 1820.
Systema algorum, 1824.

Elias Magnus Fries was born at Femsjö, Småland, Sweden, the 15th of August, 1792, received his Ph. D. degree in 1814, became docent at Upsala in 1814, and professor and director of the Botanical Garden in 1851—'63. He died at Upsala the 8th of February, 1878. The place Agardh held in algology, Fries can be said with fully as good a right to have held in mycology It is especially the higher fungi, and above all the *Hymenomycetes*, which have been treated with a master's hand by him. In his large works we find many American species described, and still more that are common to the Old and the New World.

Systema mycologicum, sistens fungorum ordines, genera et species, 1821—'29. With a supplement, 1830—'32.

B. Greenland and Arctic America.

With the nineteenth century began an active period in the investigation of polar regions. It was especially Arctic America that was an object for explorations. During this time Sabine, Ross, Parry, and Franklin undertook their famous expeditions. The following Danes added not a little to the knowledge of the flora of Greenland and the neighboring islands. The first one belongs rather to the preceding period, but is included here, as his work is closely connected with the work done later.

Captain Morten Wormskjöla was born at Copenhagen the 16th of January, 1783. He made a journey to Greenland in 1812—'14, and another around the world in 1815—'19, resided in Kamtschatka 1816—'18, and died in Gaunö, Denmark, in 1845. He brought home a fine collection of plants. At least one American plant is named after him, *Veronica Wormskjoldii,* which grows in Greenland and Arctic America as well as in the Rocky Mountains.

Count Raben made a journey to Greenland in 1823 and brought home a collection, which was determined by Hornemann.

Wilhelm August Graah was born the 24th of October, 1793, and died in 1863. He made several journeys to Greenland, the first in 1823. On his third journey, 1828—'31, he wintered at Nanolatic, Nubarbik, and Julianehaab. He was director of the Greenland Company in 1832—'50, and appointed captain in 1840.

Undersögelse Reise til Ostkysten af Grönland, 1832.
Expedition to Search for the Lost Colonies on the East Coast of Greenland.

Jens Lorens Mastue Vahl, son of M. Vahl, was born the 27th of November, 1796, was for a long time librarian of the Botanical Garden at Copenhagen, and died the 12th of november, 1854. Vahl traveled in Sweden, Germany, Austria, France, and Spitzbergen. He made one journey to Iceland and another to Greenland in 1828—'36. From his hand is the following publication:

Voyage en Island et au Grœnland, 1841.

He also contributed to *Flora Danica* and to "Naturhistoriske Bidrag til en Beskrivelse af Grönland" by Rink.

Hans Christian Lyngbye was born at Blendstrup, Denmark, the 29th of June, 1782. He was a minister of the gospel, and died at Söeborg the 18th of May, 1837. He was especially interested in water plants; contributed to *Flora Danica*, and is the author of

Tentamen Hydrophytologia Danicæ [which also included Greenland], 1819.

Jens Wilken Hornemann was born at Marstal, Aerö, Denmark, the 6th of March, 1770, received the honorary degree of Ph. D. in 1836, was professor of the university of Copenhagen 1808—'39, and died in Copenhagen in 1841. He was one of Denmark's most prominent systematic botanists, and added much to the knowledge of the flora of Scandinavia. He determined the collections made by Count Raben, Captain Graah, and others. Besides, he published the following works which contain descriptions of North American plants:

Dansk Oekonomisk Plantelære, 1837.
Hortus botanicus Hafniensis, 1813—'15.
Bemärkninger om Vegetationen i Grönland samt nogle der af Wormskjöld og Giesseke fundne sjeldne Planter, 1815.
Om Grönlands flora, 1832.
Flora Danica, Vols. 8—13, 1810—'40.

C. West Indies.

Peder Eggert Benson was born at Vesterskov on Lolland, Denmark, the 27th of October, 1788. He took his pharmaceutical examination in 1814, and arrived at St. Croix in 1817, where he practiced as apothecary. In 1822 he was elected superintendent of the natural history collections made by the order of the government. In 1848 he returned to Copenhagen, where he died the 24th of July, the same year. He made large collections which were sent to Copenhagen, and carried on an extensive correspondence, especially with Hornemann.

Om den vestindiske Salop, dens Dyrkning, Tilberedelse og almindelige Egenskaber, 1828.

Peter Ravn was born in Dröbak, Norway. In 1816 he took his chirurgical examination and became ship-surgeon on a Danish man-of-war. As such he visited, as early as 1820, the Danish West Indies and Porto Rico. In 1830 he became surgeon of the garrison on St. Thomas, and died in 1839. He collected plants in the Danish West Indies, Crab Island (Vieques), and Curacao. Although a man of poor health, he made large collections and corresponded with Prof. A. P. Candolle at Geneva and Prof. Horneman at Copenhagen.

Hans Baltzar Hornbeck was born the 9th of January, 1800, at Copenhagen. In 1829 he took his chirurgical examination, and went out the same year as ship-surgeon on the government vessel "Diana", to the West Indies. Two years later he took his examination as doctor of medicine and moved to St. John as practicing physician. He returned to Denmark in 1844, and died in 1870. He was an ardent collector, and corresponded much with Prof. Schouw in Copenhagen.

Johan Emanuel Wikström was born at Venersborg, Sweden, the 1st of November, 1789, became doctor of medicine in 1817, and was director of the Botanical Museum at Stockholm in 1818—'56. He died the 4th of May, 1856. For many years he published "Öfversigt af Svenska Vetenskapsakademiens handlingar." There are numerous publications from his hand, but only the following, as far as the writer knows, refer to American botany. They were principally based on the collections made by Dr. Fahlberg, Euphrasen, Richard, l'Herminier, Bertero, and Forström.

Öfversigt af ön Sanct Barthelemis flora (6 new species), 1826.

Öfversigt af ön Guadeloupes flora (21 new species), 1828.

Enumeration of Plants of St Eustache and Saba.

Den amerikanska Agaves eller den så kallade hundraåriga aloens naturalhistoria.

6. HOOKERIAN PERIOD, 1840—1889.

The appearance of Hooker's *Flora Boreali-Americana*, 1829—'40, and about the same time of Torrey and Gray's *Flora of North America*, 1838—'43, marks the beginning or rather the end of a period, at least as far as North American botany is concerned. These two books represent the work done during the Candollean period of two decennia of most active work. The new period was also an active one, for during this were undertaken the botanical explorations connected with the Mexican boundary survey, the Pacific Railroad surveys and Hayden's geological surveys. Nuttall, Torrey, and Engelmann were still at work during the earlier part. C. C. Parry, Hall and Harbour, Bigelow, Watson, Thurber, Wolf, Porter, Coulter, Palmer, Brandegee, Lemmon, Bolander, Kellogg, Greene, etc., were exploring the West; Palmer and Pringle began their work in Mexico, and the Macouns, father and son, theirs in Canada. The systematic part, at least on the flowering plants, passed over almost exclusively to one institution, viz. Harvard, where Gray was the leading spirit.

Bentham and Hooker's *Genera Plantarum*, in which was inaugurated modifications and improvements on the Candollean system of classification, appeared about the middle of this period, 1862—'83. It would hardly be advisable to assign as the beginning of a new period the time when this appeared; for the "Bentham-Hookerian system" differs in no essential respect from that of De Candolle and had little effect on botany at large. The "Genera", however, have been of inestimable value, for no work contains such good and complete descriptions of the genera of the world as this.

The following work was done by Scandinavians during this period:

A. United States and Canada.

Thure Ludwig Theodor Kumlien was born at Herrlunda, Västergötland, Sweden, the 9th of November, 1819, graduated at Skara Gymnasium, and was for some time a pupil of Elias Fries at Upsala. He emigrated to America in 1843 and settled near Lake Koshkonong, Wis. For twenty years he made collections for the museums at Upsala, Stockholm, Leyden, the British Museum, and the Smithsonian. He was a zoologist as well as a botanist, and a great lover of nature. In 1867 he became instructor in botany and zoology at Albion College, and in 1883 conservator of the Milwaukee Public Museum. He died the 5th of August, 1888. He published very little. The only botanical publication, as far as the writer knows, is the following:

On the Rapid Disappearance of Wisconsin Wild Flowers, 1876.

Jacob Georg Agardh, son of C. A. Agardh, was born at Lund, Sweden, the 8th of December, 1813, received his Ph. D. degree in 1832, became docent at Lund in 1834, extra-ordinary professor in 1847, and professor in 1854, retired in 1879, and died the 17th of January, 1901. He was one of the most prominent phycologists in the world, and specialized in the marine algæ, especially the red sea-weeds. He has written little that bears directly on American botany, but his principal work, "Species, genera et ordines Algarum", comprises the whole world, and therefore contains many American plants. The first one given below contains more North American species than exotic ones. The following are from his hand:

Synopsis generis Lupini, 1835.
Nya alger från Mexico, 1847.
Species, genera et ordines algarum, 1848 –'63.
Bidrag till kännedom af Grönlands Laminarier och Fucaceer, 1872.
Till algernas systematik, 1872—'90.
Grönlands Floridier och Ulvaceer.

Nils Johan Anderson was born at Gärderum, Småland, Sweden, the 20th of February, 1821, received his Ph. D. degree in 1845, was lector at the Gymnasium of Stockholm in 1851—'53, and director of the Botanical Museum in 1856—'79. He died

March 27, 1880. In 1851—'53 he was the botanist of the journey around the world of the Swedish man-of-war Eugenie, on which tour the Galapago Islands were especially studied. Anderson was the most prominent salicologist of his time, and numerous willows from America as well as elsewhere have been described and named by him. The works from his hand that bear on North American botany are the following:

Salices boreali-americanæ, A Synopsis of the American Willows, 1858.
Monographia Salicum hucusque cognitarum, 1867.
Salicaceæ in De Candolle's Prodromus, 1868.

Veit Brecher Wittrock was born at Holm, Dalsland, Sweden, the 5th of May, 1839, received the degree of Ph. D. in 1866, was appointed docent at Upsala the same year, and professor in 1878. The following year he became director of the Botanical Garden at Stockholm. He is a prominent algologist and a specialist on green algæ. The following publications refer more or less to American plants:

Algologiska studier, 1867.
On the Development and the Systematic Arrangement of the *Pithophoraceæ*, a new order of Algæ [all Tropical, some West Indian], 1877.
Prodromus Oedogoniorum, 1874.

Sextus Otto Lindberg was born at Stockholm the 29th of March, 1835, received his Ph. D. in 1865, and became professor and director of the Botanical Garden at Helsingfors, Finland, in 1865. He died there the 20th of February, 1889. He was one of the most prominent bryologists of the world, and is the author of a new system of arrangement of the genera and species of mosses. Works that bear directly on the North American flora are the following:

Revisio critica iconum in opere Flora Danica muscos illustrantium, 1871.
Europas och Nord-Amerikas hvitmossor, 1882.

B. Greenland and Arctic America.

In 1870 began a series of expeditions to Greenland and other parts of Arctic America; but before this time several collections had been sent to Copenhagen by men who had made longer or shorter stays in Greenland. The most important of these were made by

Captain Norman,

Dr. L. Schiödte, who was a physician at Ivigtut in 1867, and by

Henrik Johannes Rink, who was born in Copenhagen the 26th of August, 1819, received his degree of Ph. D. in 1844, made a journey around the world in 1845—'47, one to northern Greenland in 1848—'51, and another to southern Greenland in 1852—'68. Dr. Rink was governor of the colonies at Julienhaab and Godthaab in 1853, became general inspector of South Greenland in 1858—'68, and one of the three directors of the government explorations of Greenland in 1871—'82. He died at Christiania in 1893. He published contributions as follows:

Grönland, geographisk og statistisk beskrevet, 1852—'57. [Natural history contributions to this were made by J. Reinhart, J. C. Schiödte, O. A. L. Mörch, C. Luetken, and J. Lange (See below.).]

Greenland, 1877. [The botanical account in this was by R. Brown (Campst.) and J. Lange.]

Salomon Thomas Nicolai Drejer was born at Eveldrup, Viborg, Denmark, the 15th of February, 1813, became docent at the university in 1839, and died at Copenhagen the 21st of April, 1842. He was an acknowledged authority on sedges, especially the genus *Carex*. He described numerous new species of this genus, of which not a few are found in America. The most important work from his hand is

Revisio critica Caricum borealium in terris sub imperio Danico jacentibus inventarum, 1841.

In 1870 and 1871 two Swedish expeditions were made to Greenland under Prof. Nordenskiöld. The botanist of the first expedition was S. Berggren; of the second, T. E. Fries.

Sven Berggren was born at Hör, Skåne, Sweden, the 12th of August, 1837, received his Ph. D. degree in 1865, became docent in 1866, extra ordinary professor at Upsala in 1881, and professor at Lund in 1898. He made a journey to Spitzbergen in 1868, to Greenland in 1870, and to New Zealand in 1874—'75. The following contributions are from his hand:

Alger från Grönlands inlandsis, 1871.

Förteckning öfver kärlväxter och mossor från Grönlands-expeditionen 1870, 1871.

Bidrag till kännedom om fanerogam-floran vid Disko-bugten och Auleitsivikfjorden på Grönlands västkust, 1872.

Undersökning af mossfloran vid Disko-bukten etc., 1875.

Theodor Magnus Fries, son of Elias Fries, was born at Femsjö, Småland, Sweden, the 28th of October, 1832, received his Ph. D. degree in 1857, became docent the same year, was professor at the university and director of the botanical garden in 1877—'99. He accompanied Nordenskiöld to Spitzbergen in 1868 and to Greenland in 1871. Some of his works which bear directly on North American botany are the following:

Lichenes Arctoi Europæ Grœnlandiæque hactenus cogniti, 1861.
Grönland, dess natur och invånare, 1872.
On the lichens collected during the English polarexpeditions 1875—'76, 1879.

The botanical collections of these expeditions have been worked up by several other Swedish botanists. The principal of these are:

Jacob Georg Agardh. See page 25.

Frans Reinnold Kjellman. See page 32.

Carl Fredrik Otto Nordstedt was born at Jönköping, Sweden, the 20th of January, 1838, became conservator of the Botanical Museum at Lund in 1880, received the honorary degree of Ph. D. in 1881 and the title of professor in 1903. He has been for many years the editor of the "Botaniska Notiser". He has made extensive collections, and is an acknowledged authority on fresh-water algæ. He has published:

Desmideer samlade af Sven Berggren under Nordenskjöldska expeditionen till Grönland, 1870. 1885.
Ueber einige Characeen aus Porto Rico, 1888.

In 1876 began a series of expeditions to Greenland, undertaken to a great extent by the Danish government. The results of these expeditions have been printed in that excellent work which is known under the title

Meddelelser om Grönland.

The principal collectors on these expeditions were:

Andreas Nikolaus Kornerup, born at Copenhagen the 7th of February, 1857, became docent at the Agricultural College in 1880, and died the 3rd of September, 1881. He was the botanist of Steenstrup's expedition in 1876 and of Captain Jensen's in 1878—'79. His rich botanical collections were determined by Lange. He also contributed to *Meddelelser om Grönland*. The most important of these articles are:

Bemærkninger om Grönlands almindelige natur.
Om det organiske Liv paa den östlige Nunatak.

Knud Johan Vogelius Steenstrup was born the 7th of September, 1842, at Mov, Aalborg, took his pharmaceutical examination in 1863, became assistant in the Mineralogical Museum in 1866, and has been since 1871 the geologist of the Danish explorations of Greenland. He received the honorary degree of Ph. D. in 1894. He made two expeditions to Greenland, one in 1876 to Julianehaab, and another in 1878—'80 to North Greenland. On the first Docent Kornerup was the botanist; during the second Steenstrup made the botanical collections himself.

Gustav Frederik Holm was born in Copenhagen in 1849 and became captain in the marine in 1885. He partook in the expedition under Steenstrup in 1876. He led an expedition to South Greenland in 1880—'81, and another to East Greenland in 1883—'85. He published,

Den Danske Konbaadsexpeditionen til Grönland, 1883—'85.

*C. Petersen**, Ph. Cand., was the botanist of the expedition to South Greenland in 1880 under Captain G. F. Holm.

Jens Arnold Diderich Jensen was born at Flensborg the 24th of July, 1849, became captain in the marine in 1886, bureau-chief of the marine department in 1887, and retired in 1892. He made several journeys to Greenland: In 1877 to South Greenland, in 1878 to Godthaab and Fredrikshaab, in 1879, 1884 and 1885 to Holstenborg, Suckertoppen, and Godthaab. On the second of these journeys he was accompanied by Kornerup, and on the last by Dr. Sören Hansen, who acted as botanists. On the others he collected some plants himself.

N. Sylow, Ph. Cand., was the botanist of the expedition to North Greenland in 1879—'80 under Lieut. R. Hammer, and of that to South Greenland in 1883 under Captain Holm.

P. Eberlin and *N. Knutson*, Ph. Cand., were the botanists of the expedition of 1883—'85, under Captain Holm.

Carl Hartvig Ryder was born the the 12th of September, 1858, at Copenhagen, became lieutenant in the marine in 1879, and captain in 1897. He partook in Poulsen's expedition to Godthaab and Suckertoppen in 1885, made one to Upernavik in 1886, and another to the east coast of Greenland in 1891—'92, during which he himself made extensive botanical collections.

Johannes Eugenius Buelow Warming (See West Indies, page 48), and

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* I have not been able to give any biographical sketch either of him or of several of the following collectors, as those volumes of *Meddelelser om Grönland* in which the account of their work published, are not found in the libraries of the City of New York.

Theodor Holm (See under United States, page 40) were the botanists on the Fylla expedition of 1884 under Captain Norman. They visited the Disco-Godthaab district.

On the Fylla expedition of 1886, under Captain Bræm, the botanists were J. L. A. K. Rosenvinge (see below) and Theodor Holm (see United States). They visited the districts of Upernavik, Pröven, Godhavn, Holstenborg, Suckertoppen, Godthaab, and Fredrikshaab.

Nikolaj Eg Kruse Harts, M. A., was born at Randers, Denmark, the 23rd of August, 1867, and is an assistant in the Danish Geological Survey. He has had charge of several expeditions to Greenland, one to the Holstenborg, Fredrikshaab, and Tasermint districts in 1889, to Vaigattet and Holstenborg in 1890, and one to East Greenland in 1899—1902. From these he returned with many botanical specimens. During the last of these expeditions he was accompanied by Kruuse as botanist.

Botanisk Rejse beretning fra Vest Grönland, 1894.
Östgrönlands Vegetationforhold, 1895.
Fanerogamer og Karkryptogamer fra Nordöst Grönland, 1895.

Johan Martin Christian Lange was born at Ödstedgaard, Fredericia, Denmark, the 18th of March, 1818, became docent in 1846, was director of the Botanical Garden in 1856—'76, and received the honorary degree of Ph. D. in 1877. He died in Copenhagen the 3rd of April, 1898. He continued after Hornemann the publication of

Flora Danica, of which he edited Vols. 15—17.

He became much interested in the flora of Greenland, determining most of the collections made there. He left several publications, of which the following may be mentioned:

Oversigt over Grönlands Planter, 1857.
Naturhistoriske Bidrag til en Beskrivelse af Grönland, 1857.
Synopsis of Greenland's flora, 1877.
Bemærkningar om de av Cand. Kornerup i 1878 samlede Planter paa Vestkysten av Grönland. 1879.
Studier til Grönlands Flora, 1881.
Del Planter fra Nordgrönland, insamlede af Dr. Hansen, 1889.
Conspectus Floræ Grœnlandicæ in "Meddelelser om Grönland", Vol. 3.

This is by far the most important work that has appeared, treating of the flora of Greenland. The first part appeared in 1880.

The contents of this publication is as follows:

Part I. Fanerogamer og Karsporeplanter:
  [Introduction]—Lange.
  Bemærkningar om Grönlands alminderlige Natur.—Kornerup.
  [Systematic part.]—Lange.
  Tillæg om grönlandske Plantenavne.—Rink.
Part II. Tillæg til Fanerogamerne og Karsporeplanterne.—Lange.
  Grönlands Mosser.—Lange & C. Jensen.
Part III. Lichenes.—Deichmann-Branth & Grönlund.
  Fungi.—E. Rostrup.
  Marine Algæ.—Rosenvinge.
  Andet Tillæg til Fanerogamer og Karsporeplanter.—Rosenvinge,

Carl Christian Howitz Grönlund was born at Vordingsborg, Denmark, July 14, 1825, served as teacher at Haderlev College and as microscopist at Ny Carberg, Copenhagen, where he died August 10, 1901. He made a journey to Iceland in 1868 and another in 1876. He has published, besides his *Islands Flora* and the contributions to *Conspectus Floræ Grœnlandicæ*, also

Lichenes samlede i Gröuland af *Prof. Fr. Johnstrup* i sommaren 1874, 1877—'78.

Fredrik Georg Emil Rostrup, born at Steensgaard, Lolland, Denmark, Jan. 28, 1831, became teacher at the Normal School at Skaarup, 1858, honorary Ph. D. in 1894, and professor in 1902. He contributed the part on fungi in the "Conspectus".

Tillæg til Grönlands Svampe, 1888.

Janus Laurits Andreas Kolderup Rosenvinge was born at Copenhagen the 7th of November, 1858, became Ph. D. in 1888, docent at the University in 1895 and at the Polytechnic Institute in 1900. Besides his work on the *Conspectus Floræ Grœnlandicæ* mentioned above, we find, among other contributions:

Det sydligste Grönlands Vegetation, 1896.
Grönlands Halvalger, 1893.
Vegetation de la partie plus meridionale du Grönland, 1901.
Sur la vegetation d'algues marines sur les côtes du Grönland.
Nye Bidrag til Vest-Grönlands Flora. 1898.
Deuxieme memoir sur les algues marines du Grönland, 1900.
Om Algevegetationen ved Grönlands Kyster, 1900.

Jacob Severin Deichmann-Branth was born at Nykjöbing the 7th of December, 1831, was a minister by profession, and traveled in Germany and Italy. He, together with Grönlund, contributed the part on lichens in the *Conspectus Floræ Grœnlandicæ.*

Tillæg til Grönlands Lichen-Flora, 1892.

Ludwig Kumlien, the son of Thure Kumlien (see under United States, page 25), was born in Wisconsin, and died in 1902. Evidently he had inherited from his father the love of natural history. He was, however, more of a zoologist than a botanist, and was especially interested in birds. He was a field agent of the Smithsonian for a number of years and collected in Wisconsin and the New England States. He was the naturalist of the Howgate Polar Expedition in 1877—'78 to Cumberland Sound. The plants he collected were mostly from Niantilic Harbor, Annanactook, Kikkerton Island, and from the Island of Disco, Greenland. He published the report of the expedition, in which the plants were determined by Gray.

Contribution to the natural history of Arctic America, made in connection with the Howgate Polar Expedition, 1879.

Frans Reinhold Kjellman was born on Torsö, Västergötland, Sweden, the 4th of November, 1846, became Ph. D. and docent at the University of Upsala in 1872, and professor in 1883. He accompanied Nordenskjöld as botanist to Spitzbergen in 1872—'73, to Nova Zemlia and Siberia in 1875, and around the world in 1878—'80, during which journey they passed through the Behring Sea and visited Fort Clarence and the St. Laurence Island. He died at Upsala the 22nd of April, 1907. He was a prominent phycologist, and has paid attention especially to the algæ of the Arctic regions. Only a few of his works refer, however, to North American botany.

Fanerogam-floran på St. Lawrence-ön, 1883.

Om Behring-hafvets algflora, 1889.

Om Floride släktet *Galaxuara* [Species from Florida, West Indies, Mexico, etc.]

Algæ of the Arctic Sea, 1883.

Ernst Bernhard Almquist was born at Skogs-Tibbe, Upland, Sweden, the 10th of August, 1852, received his M. D. in 1882, and became professor at the Carolinian Institute at Stockholm in 1891. He was the physician and lichenologist of the Nordenskjöld expedition around Asia in 1878—'80.

Per Teodor Cleve was born at Stockholm the 10th of February, 1840, received his Ph D. in 1863, became docent the same year, and professor at Upsala in 1873. He is a prominent chemist and geologist, but also a botanist, having paid special attention to the diatoms, desmids and other fresh water algæ. He partook in a geological journey in 1868—'69 to North America and the West Indies.

Diatoms from the West Indian Archipelago, 1878.
Diatoms collected during the expedition of the Vega.
Färskvattens diatomaceer från Grönland och Argentinska Republiken, 1881.
On the diatoms collected during the Arctic expedition of Sir George Nares, 1883.
Diatoms from Baffins Bay and Davis Strait, 1896.
Synopsis of the Naviculoid Diatoms, 1894.

Johan August Berlin was born at Malsta, Upland, Sweden, the 7th of August, 1851, received his degree of Ph. D. in 1888. He was the botanist of the Nordenskjöld expedition to Greenland in 1883.

Kärlväxter, insamlade under den svenska expeditionen till Grönland 1883, 1884.

Alfred Gabriel Nathhorst was born at Väderbrunn, Södermanland, Sweden, the 7th of November, 1850, took the degree of Ph. D. in 1874, and became docent the same year. He became professor and director of the Paleophytological Museum, Stockholm, in 1884. He has made journeys to Spitzbergen in 1870, 1882 and 1898, to Greenland (with Nordenskjöld) in 1883, and to East Greenland in 1899. He is a prominent paleontologist and phytogeographer.

Botaniska anteckningar från nordvästra Grönland, 1884.
Forssatta anmärkningar om den grönländska vegetationens historia, 1891.
Två somrar i Norra Ishafvet.

Johan Georg Robert Boldt was born at Kuopio, Finland, the 3rd of January, 1861, took his Ph. D. examinations in 1891, and has been instructor of geography and history at Björneborg since 1899. He is a specialist on algæ, especially the desmids.

Desmider från Grönland, 1888.

C. West Indies.

Albert Heinrich Riise was born the 11th of September, 1810, on Aerö, Denmark. He became apothecary on the island of St. Thomas, where he remained until 1870. He died the 18th of October, 1882. He made important collections, which are preserved at Copenhagen.

Henrik Johannes Krebs was born at Svendborg, Denmark, June 8, 1821. He took his pharmaceutical examination in 1840, and went to St. Thomas in 1843. He made several journeys to North, Central, and South America, to the Bermudas, Bahamas, Cuba, St. Domingo, Porto Rico, St. John, and St. Croix. In 1853 he became Swedish-Norwegian consul, and from 1860 he was first a member and then the speaker in the local legislature of the Danish West-Indies. In 1870 he returned to Copenhagen. He made considerble collections and published the following:

Et Bidrag til St. Thomas' Flora, 1847.

Catalogue of plants found on the island of St. Thomas, 1852.

Axel Theodor Goes was born at Rök, Östergötland, Sweden, the 3d of July 1835, served as government physician on St. Bartholomew 1865—70 and died at Stockholm Aug. 20, 1897. He made collections of West Indian plants.

Vegetationen på St. Bathelemy, skildrad i ett bref 1867. [Published by Th. M. Fries.]

Carl Conrad Berg was born in Copenhagen 1845. He was a machine worker by trade, came to St. Thomas in 1864. In 1867 he had charge of the dredging of the harbor at that place and in 1897 he became "Dock-master" for an English company. He came in contact with Baron Eggers and learned the scientific names from him. He has made an extensive collection of tropical woods, especially those of St. Thomas and St. John.

Frederik Michael Liebman (See Mexico, page 36).

Anders Sandö Örsted (See Mexico and Central America).

Baron Henrik Frans Alexander Eggers was born at the city of Schleswig, the 4th of December, 1844. He partok in the war of 1864. After the end of this war, he entered the service of Austria, followed Emperor Maximilian to Mexico, 1865—67, and was taken prisoner. After his release, he traveled for some time in Mexico. He went to St. Thomas in 1870 and entered the Danish service as a lieutenant, was advanced to captain and pensioned in 1885. He has lived in Copenhagen since 1887.

He visited San Domingo in 1880, Porto Rico in 1881 and 1883; Tortola, St. Kitts, San Domingo, Hayti, Turks Islands in 1887; Hayti, Jamaica, Bahamas in 1888; Cuba in 1889; Tabago, Trinidad, Grenada, St. Vincent and Barbados in 1889—90, Tabago, Jamaica, Panama and Curaçao in 1891—93, and made extensive collections. The following publications are from his hand:

Erindringer fra Mexico, 1869.
St. Croix's Flora, 1876.
Rhizophora Mangle L., 1877.
Reynosia Griseb. En hidtil ufuldstandig kjendt Slægt af Rhamnaceernes Familie, 1877.
Naturen paa de Dansk-Vestindiske Öer. 1878.
The Flora of St. Croix and the Virgin Islands, 1879.
Et Besög paa Öen Dominica, 1880.
Die Poyale des östlichen Porto Rico, 1882.
Porto Rico, 1883.
Reise in das Innere von Sto. Domingo, 1888.
Flora of the Bahamas, 1892.
Supplement til St. Croix's og Jomfruöernes Flora, 1889.
Botanical Exploration to Cuba, 1890.
Die Insel Tobago, 1893.

Veit Brecher Wittrock (See United States and Canada, page 26).

Carl Emil Hansen Ostenfeld (See Greenland and Arctic America, page 45).

Carl Fredrik Otto Nordstedt (See Greenland, page 28).

William Nylander was born at Uleåborg, Finland, Jan. 3, 1822, received the degree Ph. Cand. in 1843 and that of M. D. in 1847. He lived in France from 1851 to 1857, when he was appointed professor at the University of Helsingfors, Finland. He returned to France in 1863 and died in Paris the 29th of March, 1899. He was perhaps the most prominent lichenologist of the world and was the author of numerous publications. Those relating to North America are the following:

Synopsis methodica Lichenum omnium hucusque cognitorum, 1858—'59.
Collectio lichenum ex insula Cuba, 1866.
Enumeration des Lichenes récoltés par M. T. Husnot aux Antilles francaises, 1868.
Circa Pyrenocarpeos in Cuba collectos a C. Wright, 1876.
Lichenes nonnulli insulæ St. Thomas Antillarum, 1880.
Enumeratio lichenum Freti Behringii, 1888.
Mexicanas plantas nuper a colletoribus expeditionis scientificæ [together with E. Fournier and E. Bescherell].
Lichenes exotici a W. Nylander descripti 1892.

Nils Gustaf Lagerheim was born at Stockholm the 18th of October, 1860. In 1889 he became conservator at the museum at

Lisbon; from 1889 to 1892 he was at Quito, 1892—5 at Tromsö, Norway, and in 1895 became professor at Stockholm. He has specialized in the lower cryptogams, especially the Desmids. The following contributions bear on American Botany.

Bidrag till Amerikas desmidieflora, 1885.

Ueber einige Arten aus Cuba, Jamaica und Puerto Rico. [Desmids found in material collected by Sintens, Swarts, and Wright], 1887.

Sur un nouveau parasite dangereoux de la Vigne, *Uredo Vialæ* in Jamaica, 1889.

Mykologische Studien, 1899.

D. Mexico and Central America.

Frederik Michael Liebman was born at Helsingör, Denmark, the 10th of October, 1813, made journeys in Germany 1835, and in Norway 1836, and became docent at the University of Copenhagen in 1837.

In 1840 he started for Mexico in company with Rathsack, a gardener, and arrived at Vera Cruz in February, 1841. Here he met the Russian botanist Karwinsky, and they traveled together for some months. He visited several places north of Vera Cruz, as for instance Antiqua, Colima, Misantla and as far north as Papantla. Then he turned south and after having visited several places he stayed for a considerable time at Hacienda Mirador on the eastern slope of Mount Orizaba. This mountain he climbed in company with the German botanist Ghiesbrecht. Then he visited Tehuacan and returned to Mirador. Rathsack returned to Denmark in 1842 with numerous boxes of herbarium specimens, samples of woods, fruits, seeds and living plants. Liebman himself undertook a journey southward, visiting the city of Orizaba, Cuicatlan, Oaxaca, etc., climbed the peaks of Zempoaltepec and El Pelado, visited among other places, San Pedro Alto, Huamamelula and even Tehuantepec, and on his return again Oaxaca and Mirador.

On the home journey from Vera Cruz, he stopped two or three weeks in Cuba. He died the 29th of October, 1856, as professor at the University of Copenhagen.

Liebman did not have time before his death to publish much from the results of these collections. Most of this fell on the shoulders of Örsted. Still the following important contributions are from Liebman's hands.

Mexicos Brægner, 1849.
Mexicos og Central-Americas Neldeagtige Planter (*Urticeæ*), 1851.
Mexicos Halvgræs (*Cyperaceæ*), 1850.
Les chênes de l'Amerique tropale (*posthumous*, edited by Örsted), 1869.

Liebman also contributed to *Flora Danica*, of which he edited the 14th and 15th volumes and a supplement.

Anders Sandöe Örsted was born at Rudkjöping, Denmark, the 21 of June, 1816, began teaching in 1837, took his M. A. degree in 1844 and the Ph. D. in 1854, was appointed docent in 1851, received the title of professor in 1860 and became full professor in 1865. He died the 3rd of September, 1872.

He made a botanical journey to the West Indies and Central America in 1845—48. His stay in the West Indies was rather short. Besides the Danish West Indies, he visited also Jamaica, where he stayed six weeks. Örsted was one of the most productive botanists, and the mere list of his publications would occupy half a dozen pages. The following contains the most important publications bearing on American botany.

Ein Reise i Guanasti i Costa Rica, 1849.
Naturens physionomie i Central America, 1849.
Central Americas Rubiaceer, 1852.
Compositæ centroamericanæ [together with Bentham], 1852.
Geographisk-statistisk Oversigt over Central-Americas Compositeer, 1852.
Leguminosæ centroamericanæ, 1853.
Scrophularinæ centroamericanæ, Labiatæ do. and Malpighiaceæ do. [together with Bentham], 1853.
Gentianeæ centroamericanæ [together with Grisebach], 1853.
Mexicos og Central-Americas Acanthaceer, 1854.
Myrtaceæ centroamericanæ [together with D. O. Berg], 1855.
Om det centralamerikanske Balsamtræ og Balsamkysten, 1856.
Plantæ novæ centroamericanæ, 1856.
Centralamerikas Lobeliaceer [together with Planchon], 1857.
Plantæ novæ centroamericanæ, 1857.
Centralamerikas Gesneriaceer, 1858.
Palmæ centroamericanæ, 1858.
Myrsineæ centroamericanæ et mexicanæ, 1861.
L'Amerique centrale, 1863.
Skildring af Naturen paa Jamaica, 1863.
Det centralamerikanska ambratræ, 1870.
Præcursores floræ centroamericanæ (*posthumous*), 1873.

Jacob Georg Agardh (See above).

7. ENGLERIAN PERIOD, 1889——.

In 1889 appeared the first fascicle of Engler and Prantl's *Natuerlischen Pflanzenfamilien*, and three years later Adolph Engler's *Syllabus*. The former [not yet completed] gives an an extensive account of all families and genera of plants, not only the flowering plants, as the *Genera Plantarum* of Bentham and Hooker and their predecessors. It was in this that the Englerian system of classification was first used, and it was in the *Syllabus* that it was first given in full. The Englerian system differs mainly from those of Bentham and Hooker and of deCandolle in the fact that Engler begins with the lower plants and advances from lower to higher forms, while the other systems begin with some of the higher families and proceed to the more simple ones. The names of the families are in most cases retained, but their relative position in many instances considerably changed. As the general arrangement of families and genera is much more natural than in other systems, Engler's system is now adopted at the leading institutions of this country. In individual cases the arrangement could be improved, and in some cases it is not as good as in the two preceding systems.

About the time that this system was made public, the two leading botanists of this country passed away, A. Gray in 1888, and S. Watson in 1892. This in itself might have been regarded as the end of a period. for the prominence of especially the former had been so great that the work of almost everyone else had been overshadowed. Now came a period of general comradeship and good-feeling, in which the tendency is: "Let also the smaller lights shine." To mention all the workers during the last eighteen years would be impossible, and it would be without the scope of this paper. During this period not only the Scandinavians on the other side of the Atlantic have taken an active part in American botany; there has grown up also a set of men in this country who have made no small contribution to the knowledge of North American botany, consisting partly of Scandinavians who in younger days immigrated, and partly of the sons of immigrants.

A. United States and Canada.

a. SCANDINAVIANS.

Nils Conrad Kindberg was born at Karlstad the 7th of August, 1832. He took his Ph. D. degree in 1857, and became lector at the College of Linköping 1860—1900. He is one of the leading bryologists in the world. He is a productive writer. The publications relative to North American botany given below (and this list is very likely not complete) can not by any means be compared in number with the works on Old World bryology.

Enumeratio muscorum qui in Grœnlandia, Islandia et Færoer occurrunt, 1888.

Bidrag till kännedom om Canada-områdets mossflora, 1890.

Checklist of European and North American Mosses (*Bryineæ*), 1894.

New or less known species of Pleurocarpous Mosses from North America and Europe, 1895.

New or less known species of Acrocarpous Mosses from North America and Europe, 1896.
European and North American Bryineæ, 1896—'98.
Genera of European and North American Bryineæ, 1897.
Mousses recoltées an Alabama, 1898.
Musci in J. Macoun, Catalogue of Canadian Plants, 1892.
European and North American *Polytrichaceæ*, 1894.
Notes sur un Hypopterygium in Canada, 1899.
Addition to the North American and European Bryology, 1900.
Bemerkungen über Nordamericanische Laubmoose, 1903.
New North American Bryineæ, 1905.

Johan Nordal Fischer Wille was born at Skjolden Haaböl, Norway, the 28th of October, 1858, received his degree of Ph. D. in 1885, became amanuensis at the Natural History Museum at Stockholm in 1883, professor at Stockholm in 1886, and professor at the University and director of the Botanical Garden of Christiania in 1893. He is a prominent phycologist, and has published considerably, but rather little that refers specially to American botany for instance:

New Forms of Green Algæ, 1899.
Studien über Chlorophyceen, 1901.
Algologiska notiser, 1903.

Johan Ivar Lindroth was born at Sibbo, Nyland, Finland, took his examination for the Ph. D. degree in 1903 and has been since 1902 teacher of Natural History at the Forestry Institute at Evo, Finland. He is specialist on parasitic Fungi. The following publications contain some North American species.

Mycologische Notizen, 1900.
Uredineæ novæ, 1901.

Carl Christensen, Ph. Cand., assistant in the Botanical Museum at Copenhagen, is an ardent fern student. He has served the world by issuing his *Index Filicum*, a work which is to the pteridologist what the Kew Index is to the phanerogamic systematist. It is even in many respects superior to the Kew Index, especially in the matter of citing synonyms. As yet, Mr. Christensen has published but little referring to American Botany. Of these the most important are:

American species of Leptochilus section Bolbitis, 1904.
Index Filicum, 1905.

b. SCANDINAVIAN-AMERICANS.

August Gustaf Eisen was born at Stockholm, Sweden, the 2nd of August 1849, received his degree of Ph. D. in 1872 and became docent in Zoology at Upsala the same year, but emigrated to America. He is a prominent zoologist, has made several journeys to Mexico and Central America, and collected botanical as well as zoological specimens. He is a member of the California Academy, whose President he was in 1905.

Explorations to the Cape Region of Baja, California, 1894—'95.
Biological Studies of Figs, etc., 1896.

Herman Theodor Holm was born the 3rd of February, 1854, at Copenhagen. He was the naturalist of the Danish North Pole Expedition of 1881—82 and accompanied Warming to Greenland in 1884 and Rosenvinge in 1886. In 1888, he emigrated to America, and became assistant botanist of the United States Department of Agriculture, 1893—96. He is a specialist in anatomy and morphology of flowering plants. He received his Ph. D. degree in 1902. He has published many papers on plant anatomy. The following are some of those referring more especially to North American botany:

Contribution to the Flora of Greenland, 1896.
Catalogue of Plants Collected by Messrs. Schubert, Stein, and White on the East Coast of Baffin's Land and the West Coast of Greenland, 1900.
Allies of *Stellaria media*, 1901.
Biological Notes on Canadian Species of *Viola*.
On Some Canadian Species of Gentians, 1901.
On the genus *Arctophila* Rupr., 1902.
Studies upon Cyperaceæ, I—XXIV, 1896—1905.

John H. Sandberg was born the 24th of July 1848, at Broby, Skåne, Sweden. He received his college education at Lund and also studied pharmacy in Sweden. He came to America in 1868 and located at Minneapolis in 1887. He studied medicine in this country has been practicing at Jenkins and Minneapolis, Minnesota. He is an enthusiastic collector and brought together a large herbarium of Minnesota plants, which some years ago was secured by Gustavus Adolphus College at St. Peter, Minnesota. In 1892 he became a field agent of the division of botany, United States Department of Agriculture, and collected in company with D. T. MacDougal and A. A. Heller, in Northern Idaho and adjacent Washington and Montana, and the following year in company with John B. Leiberg in the same region.

John B. Leiberg, was born the 7th of October, 1853 at Malmö, Skåne, Sweden, where he graduated from the Gymnaseum, arrived in America in 1868, and settled in 1880 near Lake Coeur d'Aleen, Idaho. He accompanied Dr. Sandberg on his second botanical expedition to the mountains of Idaho in 1893, acted as field agent for the Botanical Division of the United State Department of Agriculture the summers of 1895 and 1896, and collected in Idaho, Washington, Nevada, and Oregon. In 1897, he became connected with the United States Geological Survey, up to 1903, and in 1905—6 carried on investigations in reference to the timber supply of the Forest Reserves of Montana, Idaho, Oregon, California and Arizona and was Forestry Inspector in the Philippines in 1904—5. The following publications are from his hand.

Contributions to the Flora of Iowa, 1870.
Contributions to the Upham's Flora of Minnesota, 1880.
General Report on a Botanical Survey of the Coeur d'Alene Mountains in Idaho, 1895.
Delphinium viridescens and *Sambucus leiosperma*, 1897.
The Bitterroot Forest Reserve, 1899.
The Priest River Forest Reserve, 1899.
Forest Conditions in the Northern Sierra Nevada, California, 1902.
Forest Conditions in the San Francisco Mountains Forest Reserve, Arizona [with T. F. Rixon and A. Dodwell].

Aven Nelson was born at Keokuk, Iowa, the 24th March, 1859, his parents being Norwegians. He received his degree of M. S. in 1890, A. M. 1892, and Ph. D. 1904. He has been professor of biology at the University of Wyoming since 1887. He is a prominent systematic and economic botanist, has made extensive collections in the Rocky Mountain region, especially in the state of Wyoming, and has built up the largest herbarium found within the Rocky Mountain states. He is one of the most prolific writers on systematic botany, and hundreds of new species have been described by him. The following are the most important of his publications:

First Report on the Flora of Wyoming, 1896.
The Worst Weeds of Wyoming, 1896.
New Plants from Wyoming, I—XV, 1898—1904.
Rocky Mountain Species of *Thermopsis*, 1898.
The Trees of Wyoming and How to Know Them, 1899.
The Western Species of *Argallus*, 1899.
New Species of *Oreocarya* and its Allies, 1899.
Some Species of *Tetraneuris* and its Allies, 1899.
Some Notes on the Flora of Yellowstone National Park, 1899.
Som Native Forage Plants on Alkali Soil, 1899.

Some Rocky Mountain *Chrysothamni*, 1900.
Cryptogams of Wyoming, 1900.
Contributions from the Rocky Mountain Herbarium, I—VII, 1900—'06.
Broom-grasses of Wyoming, 1901.
An Analytical Key to Some of the Common Plants of the Rocky Mountain Region, 1902.
The Genus *Hedysarum* in the Rocky Mountains, 1902.
Native Vines in Wyoming Homes, 1902.
Psilostrophe, a Neglected Genus of Southwestern Plants, 1903.
The Wheat-grasses of Wyoming 1903.
Plantæ Andrewsianæ, 1904.
New Plants from Nevada, I—II, 1904—'05.
Plantæ montroseneses, I [together with Kennedy], 1906.

Per Axel Rydberg was born the 6th of July, 1860, in Ohd Parish, Westergötland, Sweden, and studied at the Royal Gymnasium at Skara, where he was graduated in 1881. The following year, he emigrated to America. From 1884—1893 he taught at Luther Academy, Wahoo, Neb. He received his M. A. degree at the University of Nebraska in 1895 and his Ph. D. at Columbia University, New York, in 1898; was professor of natural sciences and mathematics at Upsala College, Kennilworth, N. J., 1895—6 and 1897—9, and is since that time one of the curators of the New York Botanical Garden. In the summers of 1891—93, 1895, and 1896 he was a field agent of the United States Department of Agriculture and collected in western Nebraska, the Black Hills of South Dakota, Montana, Idaho, Wyoming and Colorado. In 1897, 1900, and 1905 he collected for the New York Botanical Garden in Montana, Colorado, California, and Utah. The list of his publications is omitted for obvious reasons.

List of Papers Published by Dr. P. A. Rydberg.*

On the American Black Cottonwood, 1893.
Flora of Nebraska. Part 21, Rosales, 1895.
New species of *Physalis*, 1895.
Flora of the Sandhills of Nebraska, 1895.
Flora of the Black Hills of South Dakota, 1896.
The North American species of *Physalis* and related genera, 1896.
Notes on *Potentilleae.*, I—VI, 1896—7.
Notes on two western plants, 1897.
Antennaria dioica and its North American allies, 1897.
Rarities from Montana, 1897.

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* *Editor's Note.* This paper would be lacking in a most important particular, if the writings of its author were omitted. The editor, for that reason, takes the liberty to here insert as complete a list as he has been able to secure of the published papers of Dr. P. A. Rydberg to the present date. J. A. UDDEN.

Report on the grasses and forage plants of the Rocky Mountain region, (together with C. L. Shear), 1897.

A monograph of the North American Potentilleae, 1898.

The ceeptose Willows of Arctic America and the Rocky Mountains, 1899.

Delphinium carolinianum and related species, 1899.

New species of the western United States, 1899.

An annotated catalogue of the Flora of Montana and the Yellowstone National Park, 1900.

What is *Prunus insititia?* 1900.

Composition of the Rocky Mountain Flora, 1900.

Studies of the Rocky Mountain Flora, I—XVII, 1900—7.

The American species of *Limnorchis* and *Piperia*, 1901.

Further notes on the *Potentilleae*, 1901.

Is the Whitefruited Strawberry of Pennsylvania a native species? 1901.

The North American Twinflowers, 1901.

The Oaks of the Continental Divide north of Mexico, 1901.

Our yellow Lady's-Slippers, 1902.

A new station of *Isotria affinis*, 1902.

Some generic segregations, 1903.

Explorations in Utah, 1905.

Penthoraceae (in the North American Flora), 1905.

Parnassiaceae (in the North American Flora), 1905.

Astragalus and segregates as represented in Colorado, 1905.

Saxifragaceae (in the North American Flora, together with J. K. Small), 1905.

Hydrangiaceae (in the North American Flora, together with J. K. Small), 1905.

Flora of Colorado, 1906.

Julius Hjalmar Flodman was born the 23rd of September in Heda Parish of Östergötland, Sweden. While he was a small boy, his father emigrated to America in 1868 and settled in Polk County, Nebraska. Flodman graduated at Augustana College, Rock Island, Ill., in 1890, and received the degree of A. M. in 1900, has been teaching at Luther Academy, Wahoo, Neb., since 1890, except one year, when he attended the University of Nebraska. He accompanied the writer on two of his botanical expeditions, viz. to western Nebraska in 1891, and Montana in 1895, and distributed sets of herbarium specimens collected on the last mentioned expedition.

Alexander Pierce Anderson was born at Red Wing, Minnesota, his parents being Swedish. He received his degree of A. M. in 1895 and of Ph. D. in 1897. He was botanist and bacteriologist at Clemson College, S. C., 1897—9, assistant professor of Botany at the University of Minnesota, 1899—1900, biologist and entomologist at Clemson, 1900—1. He is the inventor of the famous "Puffed Rice" and other starchy products. He is now the botanist and experimental chemist of a company, which is engaged in developing his discoveries and inventions. The following systematic and economic papers are from his hand:

Diseases of Plants, 1898.
A New *Tilletia* parasitic on *Orysa sativa*, 1899.
Rice Blast and a New Smut on the Rice Plant, 1899.
Tilletia horrida Tak. on Rice Plant in South Carolina, 1902.
Dasyscypha resinaria, causing the canker growth on *Abies balsamea*, 1902.

Philip Dowell was born at Attica, Indiana, the 3rd of December 1864, his father being a Swedish-American clergyman. He received his degree of A. B. in 1885, A. M. in 1895, and Ph. D. in 1900, taught at Augustana College, Rock Island, Ill., in 1889—90; at Hope Academy, Minnesota, in 1890—1; at Upsala College, Brooklyn, 1896—7; was professor of sciences at Muhlenberg College, Allentown, Pa., in 1896—1902; was botanical assistant at the United States National Museum in 1902; and is now instructor in the New York High Schools since that year. He is a zoologist as well as botanist. The following botanical publications are from his hand:

Addition to the Flora of Staten Island, 1905.
Botanical Notes, 1906.
Distribution of Ferns on Staten Island, 1906.
North American Species of *Calceolaria*, 1906.
Observations on the Occurrence of Boott's Fern, 1906.

Elias Nelson was born in Sweden, Sept. 7th, 1876, came as a boy to America, studied at the University of Wyoming, were he took his M. A. degree in 1899. He was a pupil of Prof. A. Nelson. He has been a scientific aid in the U. S. Department of Agriculture in 1900, and assistant in Horticulture and Agrostology at the University of Wyoming in 1901—5, and is now the superintendent of the Experimental Farm at Bend, Oregon, since 1905. He has made extensive collections, especially in Wyoming and neighboring states. He has made a speciality of grasses and forage plants.

Revision of the Western North American Phloxes, 1899.
Some New Western Species, 1899.
Some new species of Wyoming Plants, 1900.
Shrubs of Wyoming, 1902.
Notes on certain species of *Antennaria* 1902.

Some Western Species of *Agropyrum*, 1902.
Native and Introduced Saltbushes, 1904.

Carl Otto Rosendahl was born the 24th of October at Spring Grove, Minnesota. His parents were Norwegians. He graduated at the University of Minnesota in 1901; was instructor in botany at the same institution, 1901—2; and took his Ph. D. at Berlin, Germany, in 1905. He has paid special attention to the flora of Minnesota. He has published the following:

An Addition to the Knowledge of the Flora of Southeastern Minnesota, 1903.
Die Nordamerikanischen *Saxifragineæ*, 1903.
Observation in Plant Distribution in the Renfrew District of Vancouver Island.

Pehr Hjalmar Olson-Seffer was born at Ekenäs, Finland, the 14th September, 1873, became instructor in Swedish at Mariehamn College in 1896 and of botany at Helsingfors College in 1896, made a journey to Australia and migrated to America in 1903. He became instructor in systematic botany at Leland Stanford University in 1903, and received his Ph. D. in 1904. In 1905, he made a journey to Central America and in 1906—7 a journey around the world, in order to study rubber-culture and tropical agriculture. His specialty is Phytogeography and Economic Botany. He was for a short time the director of La Zaculpa Botanical Station and Plantation in Chiapas, Mexico, and was lately appointed Governmetal Comissioner of tropical agriculture of Mexico. He is the editor of the department of tropical agriculture in the Mexican Investos.

Mexico — Rubber Experiment Station Prospectus, 1906.

Ivar Tidestrom was born the 13th of September, 1865, in the Province of Nerike, Sweden, and came to America in 1881. From 1890—5, he was a student and assistant of Prof. E. L. Greene, at the University of California, and later at the Catholic University of Washington, D. C., where he received his Ph. B.

Notes on *Botrychium virginicum*, 1905.
Notes on the Gray Polypody, 1905.
Elysium marianum [Ferns and Fern-allies of Maryland and Virginia].

J. Lunell was born at Kalmar, Sweden, the 30th of March 1851, received his license to practice medicine in Dakota in 1889, and is now a practicing physician at Leeds, North Dakota. He has made extensive botanical collections in Dakota and in Oregon. A few new plants discovered by him have been described by Prof.

A. Nelson. As far as the writer knows, the only botanical paper he has published is

The Genus *Alisma* in North Dakota, 1907.

O. M. Oleson was born near Drontheim Norway, where he also learned gardening. He came to America and settled at Fort Dodge, Iowa, in 1870, and two years later entered a drug store. In 1876—77 he attended the College of Pharmacy at Philadelphia, where he graduated. He has collected considerably in Iowa, and in 1904 in the Yellowstone Park and in 1906 in California. He is the Chairman of the Board of Park Commissioners of Fort Dodge, Iowa.

Flora of Webster Co., Iowa, [together with M. P. Somes] 1905.

B. Greenland and Arctic America.

Johan Alfred Björling was born in Stockholm the 19th of October, 1871. He was the botanist of two arctic expeditions, viz. one to Spitzbergen in 1890; the other to Arctic America, in 1892. While engaged in this expedition, he died on Ellesmereland (west of Greenland).

Frederik Christian Emil Börgesen. (See West Indies).

Christian Krause was born at Lillio, Korsör, Denmark, the 6th of June, 1867, received the degree of M. Sc. in 1895, and became adjunct professor at the College of Randers. He made one journey to West Greenland in 1897, and another to East Greenland in 1899—1902.

List of Fanerogams and Vascular Cryptogams found on the Coast 75°—66° 20′ Lat. N. of East Greenland, 1905.

Morten Pedersen Porsild was born at Store Andst, Jylland, Denmark, in 1872, became assistant in the Botanical Museum at Copenhagen in 1895, received the degree of M. Sc. in 1900 and became director of the Arctic Botanical Station at Godhavn, Greenland, in 1905. Before that time he made two journeys to Greenland, viz. in 1893 and 1902. He has published:

Bidrag til en Skildring paa Disco, 1902.

O. Gelert was born at Nybol, Sundeved, Denmark, November 9, 1862. He took his Phar. Cand. examination in 1883, served for some time as druggist, and was later employed in a sugar-refinery.

This place he was forced to leave on account of poor health. He then received a position in the Botanical Museum at Copenhagen. Here he worked especially on the arctic collection together with Ostenfeld. Their aim was to publish an Arctic Flora. The work has been continued by Ostenfeld, and the first fascicle has been published. In 1897, Gelert made a journey to the Canary Islands. He died the 20th of March, 1899, at Copenhagen.

Notes on Arctic Plants, I [Crucifers], 1897.

Per Dusen was born at Wimmerby, Sweden, the 4th of August, 1855. He is a civil engineer by profession and has made the following journeys, mostly in the interest of botany: to Kamerum in 1890—2, Terra del Fuego in 1896—7, East Greenland (with Nathorst) in 1899, and Patagonia 1904—5. He is an amanuensis at the Museum of Rio Janeiro since 1901.

Beitrage zur Laubmoosflora Ostgrönlands und der Insel Jan Mayen, 1901.
Några viktiga växtfynd från nordöstra Grönland, 1901.
Zur Kentniss der Gefässpflanzen Ostgrönlands, 1901.

Herman Georg Simmons was born at Dalby, Skåne, Sweden, the 16th of August 1866, became Ph. Cand. in 1892, and amanuensis at the Botanical Museum at Lund in 1893. He was the botanist of Sverdrup's expedition to Ellesmereland (west of Greenland) in 1898—1902. The following are his publications:

Preliminary Report on the Work of the Second Norwegian Polar Expedition 1903.
Flora of Ellesmereland, Part I, 190...

Carl Emil Hansen Ostenfeld was born at Randers, Denmark, August 3rd, 1873. He has been inspector of the Botanical Museum at Copenhagen since 1900. He has made as his specialty the study of the flora of arctic regions. The following publications referring to America are from his hand:

Om inslæbte Planter fra Ivigtut (Syd Grönland), 1902.
Flora Arctica, Part I, 1902.
***Halophila Aschersonii* [native of St. Croix], 1902.**

Hugo Gustaf Adolf Dahlstedt was born at St. Lars, Östergötland, Sweden, the 8th of February, 1856, became amanuensis at the Botanical Garden at Stockholm in 1890 and at the Botanical Museum in 1892—4. He is a specialist on several Cichoriaceous genera, especially *Hieracium*. He has furnished some contributions to the knowledge of the North American Flora. He wrote the manuscript of the genus *Hieracium* for the *Conspectus Florae Groelandicae.*

Studien über süd-und centralamerikanische Peperomien, 1900.
Studier öfver arktiska *Taraxaca*, 1905.
Arktiska och alpina arter inom formgruppen *Taraxacum ceratophorum*, 1906.

C. West Indies.

Johannes Eugenius Buelow Warming was born on Manö, Jylland, Denmark, the 3rd of November, 1841, received the degree Ph. D. in 1871, became docent at the University of Copenhagen in 1874, at Stockholm, 1882—6, and was appointed professor and director of the Botanical Garden at Copenhagen, in 1887.

He undertook in 1863 a journey to Brazil, where he remained for three years. The book published on Lagoa Santos after his return home, placed him at once as one of the leading phytogeographers of the world. In 1884 he and Theodor Holm joined the Fylla Expedition to Greenland, and in 1891 and 1892 he undertook a botanical exploration of the West Indies and South America. He was accompanied by Holger Jörgen Lassen, and Mr. Levissen, a forester, and visited Barbados, Trinidad, Venezuela, Porto Rico, and the Danish West Indies. During these travels of his he gathered extensive material and knowledge, which he used in his phytogeographical and ecological works. He drew also from the work done in the West Indies by Börgesen and Paulsen. The works that treat more or less of the North American Flora are the following:

Biologiske Optegnelser om Grönlændske Planter, 1886—'90.
Halophytstudier, 1897.
On the Vegetation of Tropical America, 1899.
Familjen *Podostemaceæ*, 1881—1901.
Om nogle arktiske Væxters Biologi, 1886.

Holger Jörgen Lassen was born at Copenhagen, July 10th, 1868, and received the degree Ph. Cand. in 1887. He partook in the Greenland Expedition of 1890, and accompanied Prof. Warming on his journey to the West Indies and Venezuela in 1891—2. He died, October 3rd, 1897. He has publishid some smaller articles on tropical America, and besides

Momenter af Västindiens geografi.

Frederik Christian Emil Börgesen was born at Copenhagen, Jan. 1st., 1866, received his Master's degree in 1891, and became librarian of the Botanical Garden in 1900. He has made several journeys in Sweden, Denmark and Norway and has made a specialty of the fresh-water algae, especially the Desmids. He made two visits to the Danish West Indies, one in 1893, the other in 1895—6, together with O. Paulsen. Here he studied especially the marine algae. He has published the following papers:

Ferskvandsalger fra Östgrönland, 1894.
Om Vegetationen paa de dansk vestindiske Öer [with O. Paulsen], 1898.
La Vegetation des Antilles Danoises [together with O. Paulsen], 1900.
Vore vestindiske Öer, 1900.
A Contribution to the Knowledge of the Marine Algæ Vegetation on the Coast of the Danish West Indies [also in Danish], 1900.

Ove Vilhelm Paulsen was born at Aarhus, Denmark, March 22nd, 1874. He made several shorter journeys in Denmark and Norway, and went with Börgesen to the West Indies in 1895—6. In 1897, he received his Master's degree and in 1898—9 he partook in the expedition to Pamir under Lieutenant Olufsen. He became assistant at the Botanical Garden in 1900. Together with Börgesen he published:

Om Vegetationen paa de Dansk-Vestindiske Öer, 1898.

Carl Emil Hansen Ostenfeld. (See under Greenland and Arctic America, page 47).

Carl Olav Ernst Hansen was born at Ölstycke, near Copenhagen, the 7th of June, 1865. He was a gardener by trade; came in 1885 to the Botanical Garden at Copenhagen; made a journey to France in 1888, where he was employed for some time at Jardin des Plantes. In 1892 he was offered to go to the West Indies and eventually take charge of an Experimental Station which was contemplated. He visited Barbadoe, Jamaica, Domingo, and St. Lucia, where he studied the botanical gardens and sugar plantations. He made collections of plants, which he sent to Copenhagen.

Mexico and Central America.

August Gustaf Eisen (See United States, page 39).

Pehr Hjalmar Olson-Seffer (See United States, page 45).

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